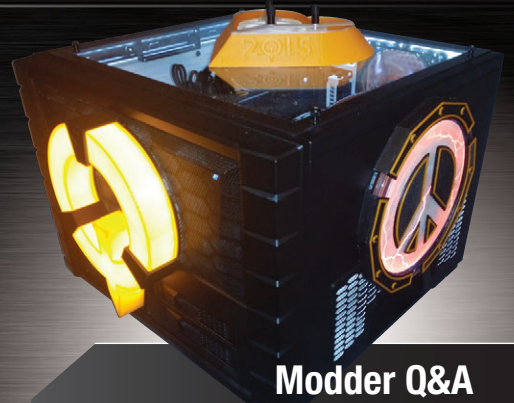


CPU

COMPUTER POWER USER



Modder Q&A
Adam "DOHCDragon" Owen



MINERVA

CHRISTIAN FROST'S STEAMPUNK MASTERPIECE
WINS OUR LANFEST 2016 MOD CONTEST

GAME ON!



 **ASTROG** ADV

Available at
amazon





35
Mad Reader Mod: Minerva, by Christian Frost



47
Modder Q&A: Adam "DOHCDragon" Owen

FRONTSIDE — P. 4

News, product release information, and stats from the tech industry.

HEAVY GEAR — P. 12

The latest PC hardware is here: reviews, product profiles, and category roundups.

HARD HAT AREA — P. 35

CPU's Mad Reader Mod winner, LAN party coverage, and in-depth looks at the latest technology.

BUYER'S GUIDE — P. 51

Building a new rig? Tired of the case your current one's in? Check out this month's Buyer's Guide.

LOADING ZONE — P. 62

Software projects, betas, updates, and more.

DIGITAL LIVING — P. 70

Trends and leisure, news from around the web, tech company interviews, and more.

BACK DOOR — P. 86

Monthly last-page interview with people who help to shape the PC industry.

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Print ISSN: 1536-7568
Online ISSN: 2473-8468

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GIGABYTE Announces AORUS 200 Series Gaming Motherboards

GIGABYTE is rolling out new product lines under its AORUS gaming brand, including new AORUS 200 Series motherboards that feature Intel's Z270 chipset. Sitting at the top of the new releases is the AORUS Z270X-Gaming 9, an extended-ATX board with distinctive white armor. The socket 1151 motherboard supports the latest 7th Generation Intel Core processors and is chock-full of technologies for gamers and overclockers. It supports four-way graphics (dual/triple/quad NVIDIA SLI; dual/triple/quad AMD CrossFire; and quad-GPU AMD CrossFireX), can handle up to 64GB of DDR4 4133, and supports triple NVMe PCIe SSDs in RAID 0. It has ports aplenty: five USB 3.1, plus one USB 3.1 Gen 2 Type C that supports Thunderbolt 3 and one USB 3.1 Gen 2 Type A; two M.2 socket 3; and two U.2. It comes with a special EKWB G-Frost Hybrid waterblock with 1/4-inch fittings to help cool the CPU's VRMs. And yes, it's RGB. MSRP is \$499.99.

Mushkin Introduces New SSDs, Including Helix, Its First M.2 Line

Among the new storage products Mushkin unveiled at CES in January was Helix, the company's first PCIe 3.0 SSD with an M.2 2280 form factor. Helix operates on the NVMe 1.2 protocol and has an SMI SM2260 controller and 3D MLC flash. It sports sequential read speeds up to 2.5GBps and sequential write speeds up to 1.1GBps. Random 4K read speeds for Helix reach up to 232K IOPS, and random 4K writes reach up to 185K IOPS. Mushkin says it will eventually roll out Helix models this year in multiple capacities ranging from 250GB to 2TB, with the first models arriving in Q1. Although the company hasn't released specific pricing, enthusiasts should be pleased when the products hit shelves. Company officials say Mushkin intends to be extremely competitive with Helix pricing across all models, but particularly at the larger capacities.



WATCHING THE CHIPS FALL

Here is the pricing information for various AMD and Intel CPUs.

CPU	Released	Original Price	Last Month's Price	Online Retail Price*
AMD FX-9590 Eight-Core (Vishera)	6/11/2013	n/a	\$199.99	\$199.99
AMD FX-9370 Eight-Core (Vishera)	6/11/2013	\$375	\$219.99	\$179.99
AMD FX-8370 (Vishera)	9/2/2014	\$199.99	\$189.99	\$184.99
AMD FX-6350 (Vishera)	10/1/2012	\$132	\$134.99	\$134.99
AMD A10-7890K (Godavari)	3/1/2016	\$164.99	\$148.99	\$148.99
AMD A10-7870K (Godavari)	5/28/2015	\$137	\$145.69	\$157.99
AMD A10-7860K (Godavari)	2/2/2016	\$116.99	\$99.99	\$114.99
AMD Athlon X4 880K (Godavari)	3/1/2016	\$94.99	\$93.40	\$96.40
AMD Athlon X4 860K (Kaveri)	8/1/2014	\$94.99	\$64.99	\$99.99
AMD Athlon X4 845 (Carrizo)	2/2/2016	\$69.99	\$67.99	\$67.99
Intel Core i7- 6950X (Broadwell E)	5/31/2016	\$1,723**	\$1,649.99	\$1,649.99
Intel Core i7- 5960X Eight-Core (Haswell)	8/29/2014	\$999**	\$1,015.99	\$1,084.66
Intel Core i7- 6900K (Broadwell E)	5/31/2016	\$1,089**	\$1,049.99	\$1,049.99
Intel Core i7- 6850K (Broadwell E)	5/31/2016	\$617**	\$609.99	\$609.99
Intel Core i7- 5930K Six-Core (Haswell)	8/29/2014	\$583**	\$579.99	\$613.64
Intel Core i7-5820K Six-Core (Haswell)	8/29/2014	\$389**	\$389.99	\$389.99
Intel Core i7-6700K Quad-Core (Skylake)	8/5/2015	\$359**	\$339.99	\$339.99
Intel Core i7-4790K Quad-Core (D.Canyon)	6/25/2014	\$339**	\$339.99	\$339.99
Intel Core i7-4790 Quad-Core (Haswell)	5/11/2014	\$303**	\$304.99	\$304.99
Intel Core i5-6600K Quad-Core (Skylake)	8/5/2015	\$249**	\$229.99	\$239.99

* As of January 2017

** Manufacturer's estimated price per 1,000



Toshiba's BG Class SSDs Include World's Smallest NVMe Drives

Toshiba's storage division has been showing off its new award-winning BG Class SSD product lines. The BG Class products are ball-grid array drives with Toshiba's BiCs FLASH memory that uses three bits per cell (TLC, or Triple Level Cell). The BG Class represents the world's smallest SSDs operating with the NVMe PCIe Gen3 x2 interface. The two models currently available in the BG lineup include one in a removable M.2 2230 format and one using the 1620 form factor. Both models are meant to be used in small and thin mobile devices and have ultra-low power requirements. The drives have a Toshiba controller and use HMB (Host Memory Buffer) technology that boosts performance despite their small size. The drives will be offered in 128GB, 256GB, and 512GB capacities, and you can expect more drives in other formats to follow. Toshiba says its new BG Class products will give users a cost-effective way to upgrade to SSDs with NVMe performance.

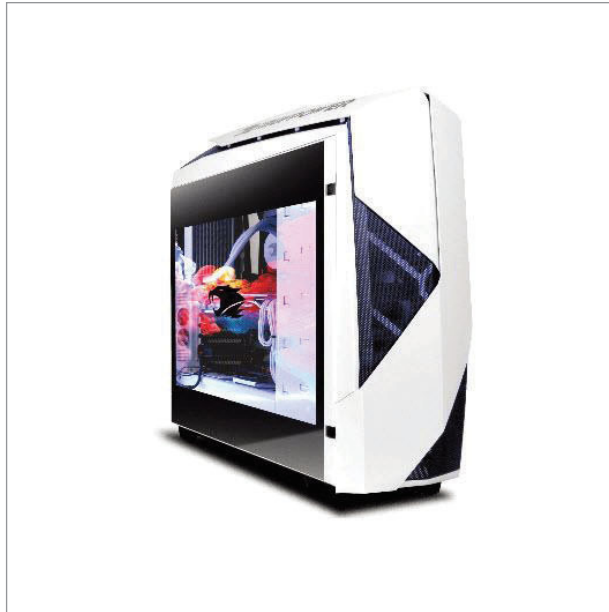
Aerocool Ventures Into Gaming Furniture Territory With AC120/220

Aerocool announced it is expanding its product focus beyond cases, power supplies, and cooling products with the launch of the AC120 and AC220, two new lines of gaming chairs. The company says the sleek design of its new chair lines was influenced by the racing stripe motif and carbon-fiber look of modern racing cars. Each model is available in six color combinations: black/white, black/blue, black/red, black/green, black/orange, and full black. The chairs can support people up to 330 pounds, and the backs recline to a horizontal position so you can lay completely flat for napping. Aerocool hasn't yet announced pricing for the two chair models, but the company says they both should be available at retailers sometime in March.



Thermaltake's The Tower 900 Is A Huge Showcase For Components

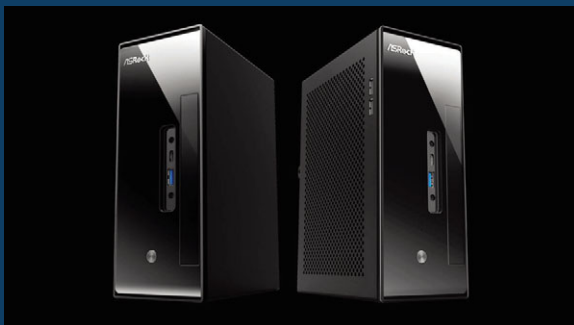
The Tower 900 case from Thermaltake was designed in collaboration with Watermod France, and it was built with liquid cooling in mind. The case is huge; it measures 29.6 x 16.7 x 19 inches (HxWxD) and weighs 54 pounds. It can hold radiators up to 560mm on both the left and right sides, plus there's plenty of room elsewhere for liquid-cooling fiends to stuff additional rads. The case handles motherboards from Mini-ATX to E-ATX, and it has room for graphics cards to 400mm; CPU coolers to 260mm; and PSUs to 220mm. You can put four 140mm fans on the left and right sides, plus two 140mm fans on the top and rear. There are six 3.5/2.5-inch drive bays with the HDD cage, one 5.25-inch bay, and two 2.5-inch bays with the HDD tray. The chassis has eight expansion slots, and it comes in white or black. The Tower 900 from Thermaltake has an MSRP of \$249.99.



iBuyPower's Snowblind Now Online

iBuyPower is now taking pre-orders for Snowblind N450 systems on its website. The Snowblind system was first revealed at the Computex trade show last June, and it was on display again at the CES trade show in January. The system uses an LCD panel as a side window in a white iBuyPower Noctis chassis. iBuyPower says it collaborated with Intel in designing the Snowblind, and Rainmeter, the desktop customization company, also created special widgets for the system. The widgets can be used as skins for aesthetic purposes or to show pertinent system information. The customization possibilities are endless, but when the LCD panel used in Snowblind is turned off, the case simply appears to have a regular clear side panel. You can outfit the Snowblind with various components, and iBuyPower currently has three variations available for pre-order: Snowblind (\$1,499), Snowblind Pro (\$1,799), and Snowblind Extreme (\$2,499). Buyers can customize components on all three models.

HARDWARE MOLE



ASRock Refreshes Mini PC Line With DeskMini RX/GTX Systems

ASRock has been hard at work on its new mini PC systems. The company announced at CES that it will refresh its small-form-factor computer lineup with new barebones systems based on its microSTX motherboard. The new motherboard is slightly longer than the Mini-STX board the company released a few months ago, and it features three ultra M.2 sockets and support for Intel's latest 7th-Generation Core processors. ASRock says the new DeskMini RX/GTX is the "world's first" system based on a microSTX form factor. The DeskMini RX Micro STX comes with an Intel i7-7700K processor and AMD RX470 MXM graphics card. The case for the system is just 2.7 liters in size. Pricing has not been released.

ASUS Announces First ROG Router, The Rapture GT-AC5300

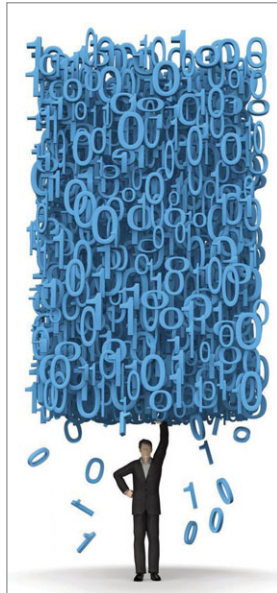
ASUS has upgraded its RT-AC5300 router with several new features and a sharp-looking Republic Of Gamers logo. The new ROG Rapture GT-AC5300 router is the first router to carry the ROG brand name. Like the RT-5300, the ROG version is a tri-band router operating with two 5GHz bands and one 2.4GHz band, and it has a total bandwidth of 5,334Mbps. It has eight antennas in a 4 x 4 MIMO setup. The ROG Rapture GT includes twice as many gigabit LAN ports as the RT unit (eight, compared with four in the RT), and it has two USB 3.0 ports compared with the RT's one. It also comes with a 1GHz quad-core 64-bit processor and a gigabyte of memory. ASUS has not yet announced availability or pricing.



Research Aims To Make Big Data More Meaningful

In many cases, big data represents the future of technology and helping consumers and companies make better decisions. But one challenge is finding systems that can store, manage, and

interpret all the data. Researchers at MIT and Israel's University of Haifa are working to solve that. At a high level, the coresets-generation technique identifies a small subset of your data that preserves the salient mathematical relationships of the entire data set, according to MIT. You can then use that smaller data set and analyze it in ways that would be prohibitively time-consuming on the full data set. MIT reports that the technique is tailored to data analysis tools with applications in areas such as natural-language processing, computer vision, recommendation systems, weather prediction, and more. To test the technique, researchers worked with a matrix mapping



every article against every word in the English version of Wikipedia and were able to come up with clusters of words that denote the 100 most common topics on Wikipedia.

New System Could Lead To Fully Automated Speech Recognition

Speech-recognition systems today rely on machine learning: poring through millions of audio files and transcriptions to learn the acoustic features that correspond with typed words, according to researchers at MIT. But a new system could reduce the cost and time needed to develop such a system by instead analyzing the correspondence between images and spoken descriptions of those images. "The goal of this work is to try to get the machine to learn language more like the way humans do," said Jim Glass, a senior research scientist at CSAIL. Researchers tested the system using a database of 1,000 images and associated recordings of free-form verbal descriptions. They then gave the system one of the recordings and asked it to retrieve 10 images that best matched the recording; the system was able to return the correct image 31% of the time. Given that, Glass said the system under development is "taking baby steps" and has a long way to go. "But it's an encouraging start."



Image source: MIT News

SOFTWARE SHORTS

YouTube VR App Lets You Experience Content In A More Immersive Way

If you have a Daydream-ready phone such as a Pixel and a Daydream View headset and controller, Google is offering a new way to experience content with its YouTube VR app. "Every single video on the platform becomes an immersive VR experience, from 360-degree videos that let you step inside the content to standard videos shown on a virtual movie screen in the new theater mode," according to Product Manager Erin Teague and Director of YouTube Creators Jamie Byrne. "More than just an amazing new technology, VR allows us to make deep, human connections with people, places, and stories," Teague



and Byrne wrote in the Official YouTube Blog. As such, they've already been working with content creators to learn about, experiment with, and create virtual reality video. Current content includes news, gaming, and cooking videos, along with videos that provide experiences such as swimming with sharks, traveling to places such as Belize, or hiking a trail, the blog states. The YouTube VR app is currently only available on Daydream View, which is Google's VR platform for Android the company launched late last year. In addition to the YouTube VR app, which has features for voice searching and the ability to follow channels you subscribe to and check out your playlists, Daydream lets you experience other Google apps in VR, including Google Photos, Google Street View, and Google Play Movies.



FTC Launches IoT Security Challenge

It's no secret that Internet of Things devices—all those “things” that connect to the internet and provide information and services with the goal of improving our lives—can be insecure. The folks at the FTC believe that private citizens are up to the task of making those devices more secure and launched the IoT Home Inspector Challenge. It will award a \$25,000 top prize to the individual or team that develops the best tool to help protect consumers from security vulnerabilities caused by out-of-date software on the IoT devices in their homes. Contestants are encouraged to create a tool with other valuable features such as addressing hard-coded, factory default, or easy-to-guess passwords, according to the FTC. Tools could be physical devices, apps or cloud-based services, or dashboards or other user interfaces. To enter, you need a video demonstrating how the tool would work, using either a prototype, mockup, or other means. Entries also need to include both an easy-to-understand abstract explaining how the tool functions and a more detailed explanation. Find more information on the competition at www.ftc.gov/iot-home-inspector-challenge.

Study: Average Broadband Speed Continues Rapid Increase

The Federal Communications Commission released its latest report on the performance of fixed broadband internet access service and, for the most part, the news is good. Broadband speeds available to the average consumer continue to increase rapidly, and service providers are delivering speeds that meet or exceed the speeds they advertise. But not everyone reaps the benefits: average DSL speeds have only increased slightly in the past five years, and satellite speeds have remained constant, according to the report, which looked at 2015 numbers. Since 2011, the median download speed has almost quadrupled, the FCC reports, going from 10Mbps in March 2011 to 39Mbps in September 2015. When looking at the speeds advertised by service providers, the FCC found that subscribers to fixed cable and fiber broadband experienced speeds that were 100% or better than advertised speeds, but the actual speeds experienced on satellite technologies were, on average, slower than those advertised. Future launches of more advanced satellites should solve this, the FCC notes. The report also delves into latency and packet loss. Little surprise here, but subscribers to DSL, cable, and fiber systems generally experienced low latency, while consumers using cable, satellite, and fiber systems had the least packet loss.



SITE SEEING

Google Spotlights 2016 In Search

2016 saw many topics set new all-time highs in search interest, according to Google, adding that “some were expected, while others were a bit more surprising.” Overall, Pokemon GO, iPhone 7, Donald Trump, Prince, and Powerball were the top five most-searched-for terms in 2016. When it comes to the tech world, Apple dominated with three of the top five terms (iPhone 7, iPhone SE, and iPhone 6S), but searches for Freedom 251 (heralded as the world's most inexpensive smartphone) and Google Pixel came in at Nos. 2 and 5, respectively. The top searches for people and

global news should come as little surprise: the U.S. election and Olympics ranked Nos. 1 and 2, with the top people searches including Donald Trump, Hillary Clinton, and Michael Phelps. You can check out the complete list from Google at www.google.com/trends/yis/2016, with breakdowns by country. In the United States, we love our green bean casseroles, which ranked as the top recipe search (followed by Brussels sprouts). We were also fascinated by knowing about hurricanes Matthew and Hermine, learning how to play Pokemon GO, and finding out how old a dog is or how many calories are in a Big Mac.

Google Trends		
See what was trending in 2016 - United States		
Searches	News	People
1 Powerball	1 Olympics	1 Donald Trump
2 Prince	2 Election	2 Hillary Clinton
3 Hurricane Matthew	3 Orlando Shooting	3 Michael Phelps
4 Pokémon Go	4 Brexit	4 Bernie Sanders
5 Slither.io	5 Zika Virus	5 Steven Avery

UBER

Job Of The Month

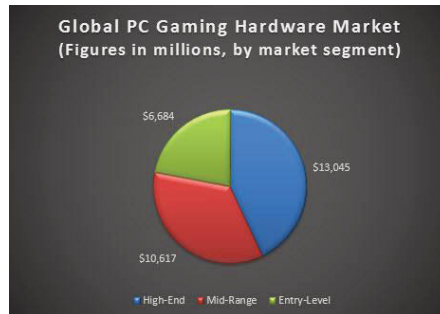
One of the fastest growing tech companies in recent years is Uber, the company that lets people looking for rides, and people willing to act as drivers, connect via their smartphones in more than 500 cities worldwide. The company is currently looking for a data engineer for its Crystal Ball forecasting platform (gotta love that name). Uber generates massive amounts of data, and it wants engineers who can take all that data and create new tools and systems to make use of it. Applicants for Data Engineer-Crystal Ball must have experience in SQL and need to have developed applications in a LAMP environment. The more you know about Hadoop/Hive, Pinot, Scuba, Redshift, and big data warehousing tech, the better. You'll work as part of a team that operates across divisions and has high visibility in the company, so this is your chance to shine. For more information on the Data Engineer-Crystal Ball position, see the Uber website. This opening is in the company's San Francisco offices.

Source: www.uber.com/careers

PC Gaming Hardware Sales = \$30 Billion

For the first time ever, global sales of PC gaming hardware have surpassed \$30 billion. The market, which comprises DIY and pre-built gaming PCs, upgrades, and accessories, is forecast by market research outfit Jon Peddie to grow at a nice 6% clip for the next several years. The research company breaks down the overall market into three segments—entry-level, midrange, and high-end—and says that computer gaming enthusiasts are in all three parts of the market. The company also reports that as more and more basic computing functions are capable of being performed by mobile devices such as the phone or tablet, the PC is becoming more of a tool for power users who want to do things such as create content, edit photos and video, and (of course) play games.

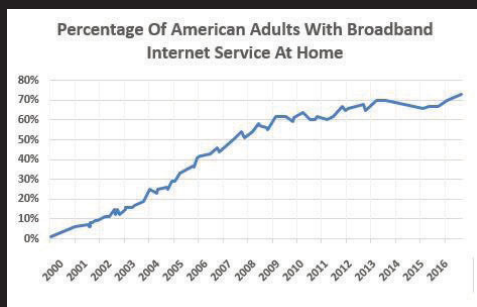
Source: [Jon Peddie Research](#)



More People Enjoying Broadband At Home

Nearly 75% of adults in the U.S. now have broadband internet service at home, an all-time high. Many people consider the service essential for modern households, but at the start of this century, broadband service was just beginning to spread in the U.S. The Pew Research Center periodically surveys homes to track internet usage and other related trends; surveyors saw an uptick in broadband access last year.

Source: [Pew Research Center](#)



RAW Numbers:

15

The percentage of U.S. households with broadband service that only use an antenna for television viewing. This percentage has increased from less than 9% three years ago. (See "More People Enjoying Broadband At Home" on this page for information on how broadband penetration in the U.S. has changed over the past 15 years.)

Parks Associates

4 billion

The installed base of smartphones worldwide at the end of 2016. This number is expected to increase about 50% to 6 billion by 2020.

IHS Markit

\$30.4 billion

Total revenue generated by the U.S. videogame industry in 2016. This total includes all related hardware, software, and peripherals sales as well as in-game purchases made by gamers.

Entertainment Software Association & NPD Group

900 billion

The number of hours worldwide that people spent using apps in 2016. That's about 122 hours each for every man, woman, and child on the planet. Nearly 90 billion apps were downloaded during the year.

App Annie

msi

US.MSI.COM

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GEFORCE® GTX 10 SERIES GRAPHICS

7th GEN. INTEL® CORE™ i7-7920HQ/7700HQ PROCESSORS	WINDOWS 10 HOME / WINDOWS 10 PRO		
GEFORCE® GTX 10 SERIES GRAPHICS	VR READY	MECHANICAL RGB BACKLIT KEYBOARD	
SWITCH BY CHERRY MX SPEED SILVER	COOLER BOOST TITAN	SUPERRAID 4	DDR4-2400
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"The GA-Z270X-Ultra Gaming's well-rounded design translated to solid numbers in our benchmarks."

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GIGABYTE GA-Z270X-Ultra Gaming

GIGABYTE's motherboard division went through a big change at the beginning of the year. The company introduced AORUS as its premium gaming brand and released a whole lineup of high-end AORUS motherboards based on the newly minted Z270 chipset. With AORUS taking most of the upper echelon of Z270 motherboards, it's fair to wonder what GIGABYTE has in store for more mainstream options. If the GA-Z270X-Ultra Gaming is any indication, it appears GIGABYTE hasn't held much back from its AORUS lineups.

The GA-Z270X-Ultra Gaming (\$164.99) stacks up well against the AORUS GA-Z270X-Gaming 5 (\$194.99) we reviewed last month. It boasts RGB LEDs along most PCB edges, under the

heatsinks and two of the PCIe slots, and between the DIMM slots. Its across-the-board illumination makes it as much of a showcase piece as any AORUS option. There's almost no drop in performance either. The GA-Z270X-Ultra Gaming supports up to 64GB of DDR4-3866, can handle SLI (up to 2-way) and CrossFire (up to 3-way), and natively supports both M.2 and U.2 PCIe SSDs.

With only one M.2 port, the storage subsystem is one area where the GA-Z270X-Ultra Gaming takes a slight step back from the AORUS GA-Z270X-Gaming 5. Due to the short list of PCIe SSDs that support U.2, we'd prefer to see two M.2 ports, rather than one M.2 and U.2 port. It's nice to see that the GA-Z270X-Ultra Gaming's M.2 slot supports type 2242/2260/2280/22110 form

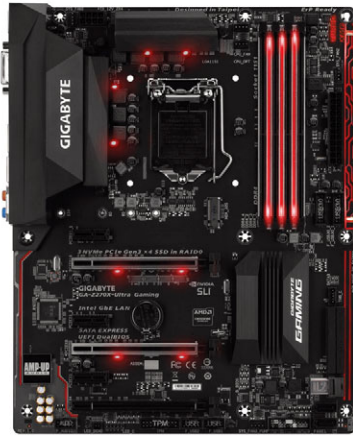
factors, so you can use any size M.2 SSD. Six 6Gbps SATA ports are also present to support conventional SATA SSDs. The SATA ports all remain active when

you connect a PCIe SSD to the M.2 or U.2 port.

Smart Fan 5 is one of the best upgrades on GIGABYTE/AORUS Z270 motherboards. On the GA-Z270X-Ultra Gaming, GIGABYTE provides you with five 4-pin, hybrid fan headers that support both PWM and voltage modes. The intelligent fan headers automatically detect what type of cooling device you have connected, such as a liquid-cooling pump or CPU, and adjust power delivery accordingly. Within the BIOS or GIGABYTE's System Information Viewer utility, you can configure a fan's rpm curve with custom temperature intervals. There are also six temperature sensors on the motherboard, and you can link each fan header to a particular sensor. This way, you have more control over heat triggers and system airflow.

Similar to previous GIGABYTE models aimed at gamers, the GA-Z270X-Ultra Gaming comes with AMP-UP Audio to enhance onboard sound quality. GIGABYTE installs Realtek's new ALC1220 that supports up to 120dB





SNR, multi-channel surround sound, and hardware decoding of DSD128. The GA-Z270X-Ultra Gaming also features a smart headphone amp that automatically detects the impedance of your headset or headphones to deliver a low, medium, or high impedance audio. If you own a USB headset with a long cable, you want to connect it to one of the two USB DAC-UP 2 ports on the rear I/O panel. The yellow USB 3.0 ports have dedicated power to provide a clean, low noise signal that can compensate for voltage drop. USB DAC-UP 2 might also help to overcome power deficiency issues with gaming gear that draws a lot of power from the USB ports.

Motherboards in the \$150 to \$175 price range typically don't boast much, if any, overclocking and troubleshooting extras. GIGABYTE equips the GA-Z270X-Ultra Gaming with enough basics to get you started. To start, there are some robust heatsinks on the VRM and PCH. The heatsinks also feature an attractive brushed aluminum exterior. To help you troubleshoot problems, GIGABYTE includes a series of status LEDs in the bottom right corner. If the

CPU, BOOT, DRAM, or VGA LED is on, the corresponding part isn't working normally.

The GA-Z270X-Ultra Gaming's well-rounded design translated to solid numbers in our benchmarks. With a little help from Intel's Core i7-7700K, the board delivered excellent scores in Cinebench 15 (988 points) and POV-Ray 3.7 (2117.36 pixels per second). Our test system's 32GB of Corsair Vengeance LED DDR4-3200MHz played nicely with the mainboard, too, producing 36GBps in SiSoftware Sandra 2016's Memory Bandwidth test. In games, we were able to top 100fps in Metro: Last Light (108fps) and Dying Light (110fps) by

adding GIGABYTE GeForce GTX 1080 Xtreme Gaming.

GIGABYTE almost always develops a few tantalizing options in the \$150 to \$175 price range, and the GA-Z270X-Ultra Gaming is an excellent example. It can support today's high-end parts without going overboard with extras that might drive up the motherboard's price, such as a second NIC or additional USB ports. The mainboard's RGB lighting also sets it apart from much of the under \$175 competition—an important note for systems with a side panel window. ■

BY NATHAN LAKE

Benchmark Results		GIGABYTE GA-Z270X-Ultra Gaming	
3DMark Fire Strike Extreme	9943	CrystalDiskMark 5.1.2 (MBps)	
Graphics Score	10836	Sequential Read (Q32T1)	2576
Physics Score	14041	Sequential Write (Q32T1)	1070
PCMark 8		Random 4K Read (Q32T1)	774.2
Creative Score	6050	Random 4K Write (Q32T1)	624.5
SiSoftware Sandra 2016		POV-Ray 3.7 (Pixels/s)	2117.36
Dhrystone AVX2 (GIPS)	208.13	Cinebench 15 (Points)	988
Whetstone AVX (GFLOPS)	122.08	Games	(2,560 x 1,440)
Multi-Media Integer AVX2 x32 (Mpixels/s)	584.63	Metro: Last Light (Very High, 16xAF; SSAA off)	108fps
Multi-Media Long-int AVX2 x16 (Mpixels/s)	214.44	Dying Light (High, AO On, AA On, Vsync Off)	110fps
Multi-Media Quad ALU x1 (Mpixels/s)	2.3	Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	89fps
Floating B/F AVX/128 (GBps, mem bandwidth)	36		

Specs: Max memory: 64GB DDR4 (DDR4-2400; Max OC: DDR4-3866); Slots: 3 PCIe 3.0 x16, 3 PCIe x1; Storage: 1 M.2 (type 2242, 2260, 2280, 22110), 1 U.2, 6 6Gbps SATA, 2 SATA Express; Rear I/O: 1 HDMI, 1 DVI-D, 2 USB 3.1 (1 Type-C, 1 Type-A), 4 USB 3.0, 2 USB 2.0, 1 PS/2, 1 Ethernet, 1 S/PDIF, audio I/O; Form factor: ATX; Warranty: 3 years

Test System Specs: Intel Core i7-7700K; GPU: GIGABYTE GeForce GTX 1080 Xtreme Gaming; Memory: Corsair Vengeance LED 32GB DDR4-3200MHz; Storage: 480GB Patriot Hellfire; OS: Windows 10 Enterprise

"... it bears a level of sophistication that you don't see in many mid-range motherboards."



MSI Z270 GAMING PRO CARBON

To compete in today's motherboard market, it's no longer enough for a mainboard to support the latest hardware and up-and-coming standards. Nor are enthusiasts surprised to see high-end amenities for onboard audio and networking—or other fancy gaming extras. Truly outstanding motherboards must now also look exceptional and be customizable to a build's color scheme. The Z270 GAMING PRO CARBON is one of the most stylish options in MSI's Z270 lineup. Carbon fiber on the heatsinks and rear I/O panel give the black PCB a nice finish, and MSI's Mystic Light RGB illumination adds some subtle flash to several areas of the motherboard, or you can turn them off if you want. A 4-pin header on the board also lets you match the board's lights to a third-party 12V RGB LED strip.

With the Z270 chipset in tow, this motherboard features several big improvements over MSI's Z170A GAMING PRO CARBON. The previous-generation board, for example, only has one M.2 slot, while the Z270 GAMING PRO CARBON

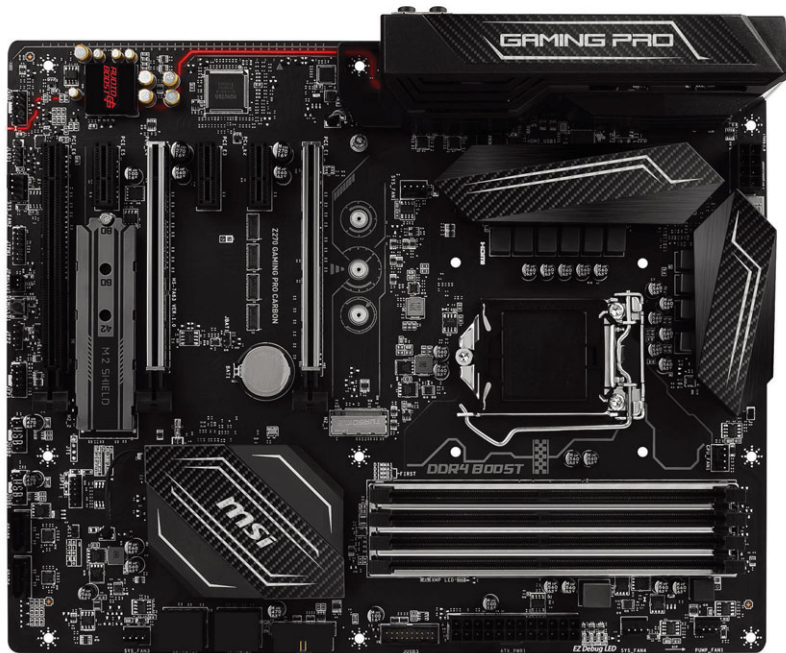
includes two M.2 slots that support Intel's Optane technology, as well as RAID configurations. For the latter, MSI provides its M.2 GENIE utility that lets you easily create RAIDs with any PCIe SSD, including add-in cards (via the bottom PCIe x16 slot) or a U.2 SSD (requires optional Turbo U.2 host card).

The top M.2 slot supports 2242/2260/2280/22110 form factor M.2 SSDs, and the bottom M.2 slot is slightly shorter and only supports 2242/2260/2280 form factors. To reduce the chance of thermal throttling on your M.2 SSD, MSI includes an M.2-sized heat spreader that should work with any M.2 SSD. The metal cover is similar to the heat spreaders you see on system memory, and it includes a thermal pad to transfer heat away from the NAND. MSI also includes an X-Boost utility that can further speed up the performance of storage and USB devices.

MSI provides USB 3.1 connectivity by adding ASMedia's 2142 USB 3.1 Gen 2 controller, which is said to double the bandwidth when you connect multiple USB 3.1 devices. The Z270 GAMING PRO

CARBON includes both a standard Type-A and a reversible Type-C USB 3.1 port on its rear panel. The USB 3.1 ports, as well as one of the USB 3.0 ports, are equipped with MSI's VR Boost technology to produce a clean, strong signal when you connect VR cables 10 feet or more in length.

When it comes to performance parts, the Z270 GAMING PRO CARBON matches up well with other mid-range Z270 motherboards. There are four DDR4 slots that support up to 64GB of 3800MHz memory. The board supports up to a 3-way CrossFire or 2-way SLI GPU configuration, and if you install two cards, each will operate at x8 speed. As we mentioned earlier, the board's bottom PCIe x16 slot can also be used with a PCIe add-in card SSD, and this slot doesn't share bandwidth with the board's M.2 or the SATA ports. The majority of the memory, GPU, and M.2 slots are protected by MSI's Steel Armor technology that strengthens the slot and shields it from EMI.



Onboard audio is taken care of by Realtek's new ALC 1220 audio processor. MSI surrounds the chip with its Audio Boost 4 technology, which helps to ensure a quality signal path to your sound devices with dedicated audio capacitors and de-pop protection circuitry. Nahimic 2 sound processing software is included, too, so you can adapt board audio to your personnel preferences. One of the new features in Nahimic 2 is a Sound Tracker feature that provides a visual indication of in-game sounds via a mini-map overlay. Networking is covered by Intel's I219V, and you can control network bandwidth using MSI's GAMING LAN utility.

The Z270 GAMING PRO CARBON did well in our benchmark tests and, most notably, the board's M.2 heat spreader appeared to improve the read and write speeds of Patriot's 480GB Hellfire in CrystalDiskMark 5.1.2. The PCIe SSD delivered 4K (Q32T1) reads of 757.6MBps and 4K random writes hit 614.3MBps. We paired the Z270 GAMING PRO CARBON with

MSI's GeForce GTX 1080 GAMING X 8G and enjoyed better than 100fps in Metro: Last Light (104.66fps) and Dying Light (112fps). Results in the processor-intensive tests were comparable to our previous testing with Intel's Core i7-7700K.

MSI makes good use of the Z270 chipset and provides several useful hardware and software additions with the Z270 GAMING PRO CARBON, such as the ASMedia 3.1 Gen 2 controller and VR Boost ports. The performance enhancements make it a good choice for gamers and early adopters. The Mystic Light illumination is flashy without blinding you to other parts of a build. Overall, it bears a level of sophistication that you don't see in many mid-range motherboards. ■

BY NATHAN LAKE

Z270 GAMING PRO CARBON

\$174.99

MSI

us.msi.com

Benchmark Results	MSI Z270 GAMING PRO CARBON
3DMark Fire Strike Extreme	9899
Graphics Score	10788
Physics Score	14036
PCMark 8	
Creative Score	5957
SiSoftware Sandra 2016	
Dhrystone AVX2 (GIPS)	207.15
Whetstone AVX (GFLOPS)	121.51
Multi-Media Integer AVX2 x32 (Mpixels/s)	588.79
Multi-Media Long-int AVX2 x16 (Mpixels/s)	213.27
Multi-Media Quad ALU x1 (Mpixels/s)	2.39
Floating B/F AVX/128 (GBps, mem bandwidth)	35.9
CrystalDiskMark 5.1.2 (MBps)	
Sequential Read (Q32T1)	2776
Sequential Write (Q32T1)	1484
Random 4K Read (Q32T1)	757.6
Random 4K Write (Q32T1)	614.3
POV-Ray 3.7 (Pixels/s)	2021.78
Cinebench 15 (Points)	942
Games	(2,560 x 1,440)
Metro: Last Light (Very High, 16xAF, SSAA off)	104.66fps
Dying Light (High, AO On, AA On, Vsync Off)	112fps
Witcher 3: Wild Hunt (Vsync Off, Unl. FPS, Ultra)	88.4fps

Specs: Max memory: 64GB DDR4 (DDR4-2400; Max OC: DDR4-3800); Slots: 3 PCIe 3.0 x16, 3 PCIe x1; Storage: 2 M.2 (slot 1 supports 2242/2260/2280/22110, slot 2 supports 2242/2260/2280), 6 6Gbps SATA; Rear I/O: 1 HDMI, 1 DVI-D, 2 USB 3.1 (1 Type-C, 1 Type-A), 4 USB 3.0, 2 USB 2.0, 1 PS/2, 1 Ethernet, 1 S/PDIF, audio I/O; Form factor: ATX; Warranty: 3 years

Test System Specs: Processor: Intel Core i7-7700K; GPU: MSI GeForce GTX 1080 GAMING X 8G; Memory: Corsair Vengeance LED 32GB DDR4-3200MHz; Storage: Patriot Hellfire 480GB; OS: Windows 10 Enterprise



"If you want to build a powerful rig, this box lets you do it."

Rosewill GUNGNIR X

Most of the time, you can tell if a particular case manufacturer "gets it" by looking at that company's latest offerings. In a market overflowing with options, those that recognize and implement current trends typically produce the best cases, and those that don't usually find themselves going out of business. Rosewill has a good track record of staying abreast of what enthusiasts value in a case, so we weren't surprised to see the GUNGNIR X arrive on our doorstep bristling with features on our wish list.

On the outside, the GUNGNIR X makes a muted artistic statement rather than shout at you. Aside from the generous window on the left side panel, an asymmetrical glossy plastic façade adorning its front panel, and an LED fan attached to the rear panel, the

GUNGNIR X is free of embellishments. On the whole, this case leans toward "restrained" rather than "garish."

To really appreciate the solid design choices Rosewill made with the GUNGNIR X, just pry off its side panels. Inside, you'll see that the GUNGNIR X is equipped to handle a wide range of components. For example, the motherboard tray is built for ATX and E-ATX mobos, but it's perfectly compatible with mATX and Mini-ITX motherboards, too. Continuing to explore the motherboard tray, the CPU cooler cutout is more than ample, while a pair of small, rectangular cutouts make it easy to run cables to the connectors on top edge of your motherboard. The GUNGNIR X's three dedicated 2.5-inch drive brackets hide on the back of the

motherboard tray, each secured with a thumbscrew.

Indeed, the GUNGNIR X goes out of its way to help you conceal the components you'd prefer to keep out of sight. A PSU shroud nearly spans the entirety of the case from front to back, leaving just enough room for you to add a radiator to the two 120mm fans preinstalled behind the front panel. The shroud also contains a pair of 2.5-/3.5-inch drive bays. A second shroud on the right side of the motherboard tray covers up a pair of cable management holes; with an ATX or E-ATX motherboard installed, only the connectors of any cables that pass through the shrouded holes should be exposed. (The main ATX power cable is an exception.) We also found plenty of room between the motherboard tray and right side panel to wrangle system cables.

Builders can round out their systems with multiple high-end graphics card and a mighty liquid-cooling loop if they choose the GUNGNIR X. Graphics cards up to 16.5 inches long, which is basically all of them, are welcome inside the case. Although the case supports radiators up to 280mm and 360mm along the front and top panels, respectively, hanging a triple rad from the GUNGNIR X's rafters isn't as simple as the spec sheet would lead you to believe. Expect an extremely tight fit unless you remove the 5.25-inch drive bay, something that—let's face it—is a questionable inclusion to begin with.

Still, the GUNGNIR X gives you a lot of case for 75 bucks. If you want to build a powerful rig, this box lets you do it. ■

BY VINCE COGLEY

GUNGNIR X

\$74.99

Rosewill

www.rosewill.com

Specs: Dimensions: 19.57 x 8.27 x 18.9 inches (HxWxD); Materials: Steel, plastic; Motherboard support: Mini-ITX, microATX, ATX, E-ATX; Drive bays: 2 x 5.25-inch external, 2 x 3.5-inch/3 x 2.5-inch internal; Fans (included): 2 x 120mm front, 1 x 120mm LED rear; Fans (optional): 3 x 120mm top; Ports: 2 x USB 3.0, 2 x USB 2.0, audio I/O



"The DXRacer Iron Series is another fantastically comfortable chair that looks as good as it feels."

Iron Series (OH/IS166/NE)

\$469

DXRacer

www.dxracer.com

DXRacer Iron Series

DXRacer makes premium chairs that appeal to those who value comfort, ergonomics, and aesthetics, in no particular order. The latest chair we've had the pleasure of reviewing is the new high-end Iron Series, model OH/IS166/NE. The latter two letters of the model indicate the color, and as usual, we opted for the green and black one.

There is a test I like to perform whenever I'm presented with an item labeled "some assembly required," and while it's hardly scientific, its results do tend to say something about build quality and the balance between form and function. Basically, it entails unwrapping and laying out all the parts on the floor, tucking the assembly manual neatly away in a drawer, and then putting the thing together using nothing more than my wits and will (and sometimes a hammer). DXRacer's chairs have always aced this test (no hammer required). So this time, I decided to see if I could go from sealed box to game-ready chair with even the lumbar and neck pillows in place in less than 20 minutes. But before I reveal whether or not the DXRacer Iron Series chair prevailed, let's get to the important stuff.

With the Iron Series, DXRacer isn't setting out to reinvent the office chair. The two-tone seat features many of the same features you've probably come to recognize as hallmarks of the brand, including the high backrest designed to deliver support from your tailbone to your occipital ridge. The five-point base of the Iron Series, like most of DXRacer's premium chairs, is constructed of aluminum and painted black.

You can't tell from the photos, but the 3-inch casters are a good deal larger than typical office chair casters, and moving the chair while seated is smooth in all directions. There is a 4-inch gas-spring lift mechanism operated using the underseat paddle on the right and the two-position paddle on the left lets you rock the chair back and lock it to your desired position. You can also tilt the back of the chair up to 135 degrees using the lever on the right and even adjust the arm rests up and down, forward and back, and angle them outward to maintain a high level of comfort for hours on end. If you've never had an office chair that is

as fully adjustable as the Iron Series from DXRacer, you're really missing out.

The chair's frame, covered in high-density mold-shaping foam, has a lifetime warranty and the accessories are guaranteed for two years. Like many of the DXRacer chairs we use in the office, this one is coated in bicast leather, which looks and feels like the real deal. You can get the Iron Series in orange, white, black, red, blue, or green. Sitting in this chair for a full workday quickly became preferable to sitting in our pricey—and decidedly bland—office chairs.

The Iron Series chair feels solid and well-made, but it's still light enough to easily move from a sitting or standing position. Getting back to my timed assembly: I managed to accomplish complete assembly in 17 minutes, and a good portion of that time was just spent wrestling with the plastic wrap covering most of the parts.

They've done it again. The DXRacer Iron Series is another fantastically comfortable chair that looks as good as it feels. ■

BY ANDREW LEIBMAN

Specs: Highlight colors: Black, red, white, green, orange, blue; Cover: leather-style vinyl and bicast leather; Adjustable back angle: 135 degrees; 4D adjustable armrests; Aluminum base; Weight limit: 275lbs.; Accessories: Headrest and lumbar cushions



"... the CULLINAN has replaced the B2 Spirit as our favorite among Rosewill's extensive case lineup ..."

Rosewill CULLINAN

In 2016, tempered-glass side panels were the trendy addition to lots of cases around the industry; costs came down, and manufacturers moved from offering just a single glass panel (usually the left, for obvious reasons) to having glass panels on both sides. PC parts maker Rosewill has upped the ante for 2017 with its brand-new CULLINAN chassis, which has tempered glass on both sides and a tempered-glass front panel.

Although it's not the first case on the market to offer a translucent front panel, it's a great addition to Rosewill's lineup and the look is accentuated by the triple 120mm LED front-panel fans Rosewill ships pre-installed with the chassis. There's a matching LED fan bolted to the back panel, and if you want you can add up to three 120mm or 140mm fans beneath the top panel (or mount a 360 radiator there). You can also replace the front-panel fans with 140s if you roll that

way, and the front panel will also support a 360mm radiator.

While we're on the subject of fans, Rosewill includes a three-position fan control switch up front by the USB and audio I/O ports. The switch's internal connector, which is located on the back of the motherboard tray, will accommodate up to five fans.

The CULLINAN sports the clean, drive-cage-free interior that's in vogue these days, thanks to a built-in metal power supply shroud, a dual-bay 3.5-inch drive cage behind said shroud, and the three 2.5-inch drive mounts Rosewill attaches to the rear of the motherboard tray. Having a clutter-free interior is even more important when your entire left-side panel is made of glass; the result of these features combined with a motherboard tray that's designed specifically to make cable management a snap means the CULLINAN will proudly show off the stuff you want to show off—and not much else. The

large cable management slots that run vertically along the front edge of your motherboard are covered by an even larger plastic shroud that helps keep things looking even cleaner.

Rosewill gives the CULLINAN removable dust filters, both beneath the power supply mount and on the top of the case, the latter being a magnetic mesh piece that snaps on and comes off easily.

Functional, builder-friendly features aside, the CULLINAN is all about creating a great-looking system, and in our estimation it delivers. In fact, the CULLINAN has replaced the B2 Spirit as our favorite among Rosewill's extensive case lineup; take a look for yourself and we think you'll see why. ■

BY CHRIS TRUMBLE

CULLINAN

\$139.99

Rosewill

www.rosewill.com

Specs: Dimensions: 19.57 x 8.54 x 18.78 inches (HxWxD); Materials: Steel, plastic, tempered glass; Motherboard support: mATX, ATX, EATX, XL-ATX; Drive bays: 2 x 3.5-inch/2.5-inch internal, 3 x 2.5-inch internal; Fans (included): 3 x 120mm LED front, 1 x 120mm LED rear; Fans (optional): 3 x 140mm front, 3 x 120mm/2 x 140mm top, 1 x 140mm rear; Ports: 2 x USB 3.0, 2 x USB 2.0, audio I/O

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"... one of the best options for power users looking to use a high-powered graphics card in a Mini-ITX rig."

REVOLUTION SFX 650W

\$124.99

ENERMAX

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ENERMAX REVOLUTION SFX 650W

With a growing number of enthusiasts building small form factor systems, we've seen a lot of case manufacturers release specially designed Mini-ITX cases that both optimize airflow and support for high performance parts. To maximum space, many of these Mini-ITX cases require an SFX power supply with standard dimensions of 2.5 x 4.92 x 3.94-inches (HxWxD). Standard ATX PSU dimensions, by comparison, are generally 5.9 inches tall and 5.5 inches long, and many high wattage models are quite a bit longer. The REVOLUTION SFX 650W is one of the highest wattage SFX PSUs on the market, and according to ENERMAX, it's the highest wattage SFX PSU with a standard 3.94-inch depth.

Outside of the REVOLUTION SFX 650W's small dimensions, the PSU offers the connectivity and features you'd expect on an enthusiast-level 650 watt power supply. The REVOLUTION SFX 650W meets the 80 PLUS Gold certification, is fully modular, and comes with a PWM controlled fan for quiet operation. The REVOLUTION SFX 650W's 80mm fan won't start spinning until load goes

above 195 watts, which means the unit will be completely silent when your PC is idle. ENERMAX also includes a bracket, should you want to use this PSU in an mATX or ATX chassis.

ENERMAX has recently overhauled the modular cabling on its PSUs, moving to either individually-sleeved cables or flexible flat cables. The REVOLUTION SFX 650W uses flat black modular cabling, and these cables are notably shorter than what comes with a full-size PSU. It's a smart design choice, because Mini-ITX cases don't have much free space to stow away excess cable. Connector options are as follows: one 24-pin main power, a 4+4-pin CPU power, two 6+2-pin PCIe, six SATA, and four Molex.

The REVOLUTION SFX 650W distributes most of its power over a single +12V rail. ENERMAX designs the +12V rail to support up to 54A (648 watts), while the +3.3V rail handles up to 18A and the +5.5V supports up to 15A. Japanese electrolytic capacitors rated for up to 105 degrees Celsius are responsible for handling the PSU's power. Internal circuitry (and by extension, any connected

component) is protected against overpower, overvoltage, undervoltage, overcurrent, over temperature, and short-circuit conditions.

We paired the REVOLUTION SFX 650W with a system running an Intel Core i7-7700K, a GIGABYTE GeForce GTX 1080 Xtreme Gaming, and 32GB of Corsair Vengeance LED DDR4-3200. It had no trouble powering the high-end hardware and was able to push through the demanding combined load of Prime95's In-Place test and Unigine Heaven 4.0. During testing, peak power reached 420 and a power factor of .986—an excellent result. In most cases, power factor was between .980 and .988.

There are a lot less SFX power supplies on the market than standard ATX PSUs, so it's smart for ENERMAX to design a SFX PSU that truly meets the needs of enthusiasts. Based on our testing, the REVOLUTION SFX 650W looks to be one of the best options for power users planning to use a high-powered graphics card in a Mini-ITX rig. ■

BY NATHAN LAKE

Specs: Maximum wattage (continuous): 650W; 12V rail: 1 54A; +5V max: 15A; +3.3V max: 18A; Efficiency rating (advertised): 80 PLUS Gold; Fan: 80mm; Connectors: 1 x 24-pin ATX, 1 x 4+4-pin EPS12V, 2 x 6+2-pin PCIe, 6 x SATA, 4 x Molex; Warranty: 5 years

Test System Specs: Processor: Intel Core i7-7700K; Motherboard: GIGABYTE GA-Z270X-Ultra Gaming; GPU: GIGABYTE GeForce GTX 1080 Xtreme Gaming; Memory: Corsair Vengeance LED 32GB DDR4-3200MHz; Storage: 480GB Patriot Hellfire; OS: Windows 10 Enterprise

Z11 NEO

**Z9 NEO
WHITE**



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CNPS10X OPTIMA
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Patriot Memory

www.patriotmemory.com

"Solid-state drives grab all the headlines, but this memory card knows how to wield its NAND, too."

Benchmark Results*	Patriot Memory LX Series 256GB
CrystalDiskMark 5.2.1	
Sequential read	83.68
Sequential write	71.09
2GB Folder Transfer	
Read	56.35
Write	15.75
*all results in MBps	

Patriot Memory LX Series 256GB

For a while, we forgot about memory cards. They were indispensable during the era of digital cameras (and they're still vital for prosumers using D-SLRs), supplying enough ammo to take thousands of shots without needing to reload. Once smartphones and cloud storage came along, casual types stopped lugging around a separate camera, which of course obviated the need for capacious memory cards. Niche markets still demanded them, but SD, CF, microSD, and other varieties of pint-sized removable storage needed to find new homes.

Leave it to enthusiasts to revitalize demand for big and fast memory cards. Photos are so 2004. Now, we're using action cameras and zipping through the sky with drones. Digital images? That's rich. Now, 4K video is all the rage, so high-performance memory cards with hundreds of gigabytes of capacity are more important than ever.

But don't count out smartphones (and tablets), either. Plenty of Android devices have expandable storage, another opportunity for truly superior memory cards to give power users a leg up.

So, apologies for the belabored introduction, but there are plenty of reasons that Patriot's recently announced 256GB LX Series microSDXC card deserves time in the spotlight. Most of the time, we turn to Patriot for DDR4 and solid-state drives, but the company churns out memory cards like the LX Series on a regular basis, too. Patriot debuted the 256GB LX Series card at CES; power users take note.

Armed with a complement of 3D TLC NAND, the new LX Series microSDXC card follows the same trend we've seen with solid-state drives. TLC NAND allows for more storage without compromising much throughput. As a result, this card can claim some fairly impressive reads and writes. According to Patriot, with the pedal to the metal, the new LX Series card cruises along at 90MBps for sequential reads. The card's maximum sequential writes are nearly as fast, maxing out at 80MBps. Bottom line: You can fill up the 256GB LX Series with massive amounts of media, whether that's hours of 4K video, thousands of hi-res images, or a mix of both. Then, when the

time comes to move everything to a PC, expect the LX Series card to make short work of the transfer.

To test the 256GB LX Series microSDXC card, we dropped it into the microSD slot of a Dell Venue 11 Pro tablet, which includes a 1.6GHz Intel Core i5-4300Y, 8GB of DDR3-1600, and a 256GB SanDisk X110 SSD. First, we pitted the card against CrystalDiskMark's sequential read and write tests. Next, we transferred a 2GB folder of assorted files to and from the card, timing the trip each direction. Predictably, the LX Series card likes to eat big bites of data: Images and videos flew back and forth between card and tablet, while tiny Office files caused throughput (particular writes) to plummet.

SSDs grab all the headlines, but this memory card knows how to wield its NAND, too. Not everyone needs a memory card with a quarter of a terabyte of storage, but for those who do, Patriot's 256GB LX Series microSDXC doesn't disappoint. ■

BY VINCE COGLEY

Specs: Capacity: 256GB; Maximum sequential read/write (advertised): 90MBps, 80MBps; Class 10; U3-qualified; SD adapter included; Warranty: Two years
Test system specs: Processor: 1.6GHz Intel Core i5-4300Y; RAM: 8GB DDR3-1600; Storage: 256GB SanDisk X110; OS: Windows 10 Enterprise



"... easy on the budget but still provides the design and quality we've come to expect from be quiet!."

be quiet! Pure Base 600

The newest addition to German PC parts manufacturer be quiet!'s case lineup is the Pure Base 600, a mid-tower chassis that is easy on the budget but still provides the design and quality we've come to expect from be quiet!.

The Pure Base 600 has a similar look and feel to its higher-priced siblings, including the smooth, black front panel and sides with the company's trademark vertical mesh vents along the left and right sides of the front panel. There are currently two variants of the case, one with the vents outlined in black, and one that has them bordered by silver trim.

Up top, you'll find a mostly smooth panel that has a few narrow vent openings near the back, but if you decide to install a top-mounted radiator as part of your cooling system and want more breathability, you can use the panel's ridged tab inserts to raise it above the rest of the panel to one of two settings. You can mount a 120, 240, or 360mm radiator beneath the top panel, and

the front panel will support one of five radiator sizes (120, 140, 240, 280, or 360mm), depending on whether you retain the Pure Base 600's two-bay 5.25-inch cage for external drives.

Elsewhere, the case accommodates a 120mm radiator on the rear panel, has a removable three-bay internal drive cage that lets you mount either 3.5- or 2.5-inch drives, and has two removable 2.5-inch drive mounts on the back of the motherboard tray. You'll find plenty of cable management holes on the tray, as well as the now-obligatory cutout for cooler mounting, and a PSU mount with rubber anti-vibration pads and a removable dust filter.

Like all be quiet! cases, the Pure Base 600 is equipped with the company's own excellent case fans, in this case a 140mm Pure Wings 2 intake fan up front and a 120mm model in the rear for exhaust. Both fans are connected to the three-step fan control switch at the top of the front panel between the power and reset

buttons, and even at the maximum speed the bigger 140mm fan produces a scant 18.8dB(A) of sound.

be quiet! designed the interior for maximum flexibility; you can install a Mini-ITX, microATX, or ATX motherboard, and if you remove the 3.5-inch drive cage near the bottom, the case will hold graphics cards up to 16.7 inches long (11 inches if you leave the cage in place). There are also numerous possible fan configurations, so just about any cooling configuration you can dream up will be welcome.

The Pure Base 600 from be quiet! has an MSRP of just \$89.90, which is impressive given both the case's good looks and sturdy construction. ■

BY CHRIS TRUMBLE

Pure Base 600

\$89.90

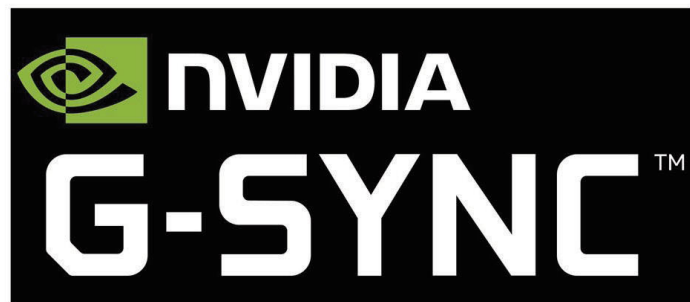
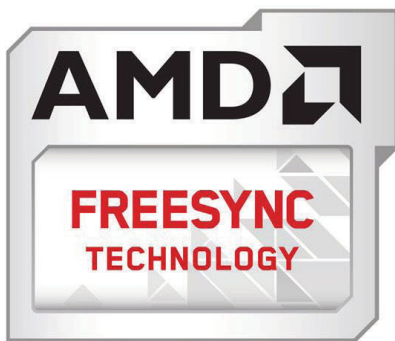
be quiet!

www.bequiet.com

Specs: Dimensions: 18.5 x 8.7 x 19.4 inches (HxWxD); Materials: Steel, plastic; Motherboard support: Mini-ITX, mATX, ATX; Drive bays: 2 x 5.25-inch external, 3 3.5-inch/2 2.5-inch internal, 2 x 2.5-inch internal; Fans (included): 1 x 140mm front, 1 x 120mm rear; Fans (optional): 2 x 140mm/3 x 120mm front, 3 x 120mm/2 x 140mm top; Ports: 2 x USB 3.0, audio I/O

State-Of-The-Art Standards

FreeSync & G-SYNC



In the quest to produce the smoothest and most realistic gameplay, power users typically purchase the most powerful graphics card (or cards) their budgets will allow. More raw GPU horsepower typically translates to better FPS (frames per second) rates, and the faster the frame rate, the smoother gameplay will appear. A high-powered GPU can also let you max out video settings to enhance effects and further immerse yourself in the game. Yet there are some graphics issues that even a pricey GPU can't completely resolve by itself.

Screen tearing, for example, occurs when a GPU's frame rate doesn't match up with the monitor's refresh rate. The result is that the display might show parts of multiple frames in a single draw, and where differences exist between those frames, noticeable artifacts will result. Classic symptoms of screen tearing

are misaligned on-screen content and fragmented scenes.

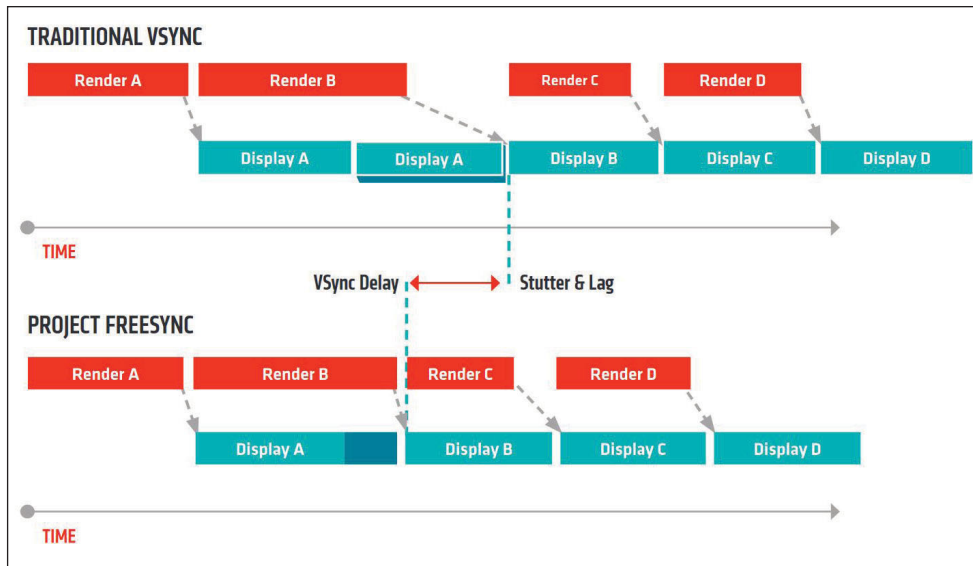
AMD FreeSync and NVIDIA's G-SYNC technologies solve screen tearing by synchronizing GPU and monitor refresh rates on a frame-by-frame basis. Because AMD and NVIDIA differ in how they implement the respective variable refresh rate technologies, both your GPU and monitor must be compatible for refresh rates to sync up. As such, you must use a compatible AMD GPU with a FreeSync-enabled display, or a compatible NVIDIA GPU with a G-SYNC-enabled display.

Recently, Team Green and Team Red raised the bar with new standards that add support for HDR (high dynamic range) to the respective adaptive-sync technologies. Titled FreeSync 2 and G-SYNC HDR, these technologies are necessary because existing HDR transport methods tend

to introduce lag when HDR is used with videogames. Similar to the variable refresh rate techniques, FreeSync 2 and G-SYNC HDR allow a GPU to convey HDR metadata directly to a compatible display. The gaming evolution never stops.

What's Wrong With Vsync?

For years, gamers have been using Vsync to combat the problem of screen tearing, and you don't have to have a specific GPU to take advantage of Vsync. But some gamers opt to disable Vsync because it can cause choppy onscreen motion. Basically, Vsync forces the GPU to render frames at a fixed cadence to create a set of completed frames, and the monitor will signal when it's ready for a new frame. Stutter can occur when your GPU's frame rate falls below the Vsync cap, which is typically 60fps.



Vsync fixes one problem (screen tearing) but introduces two others (stutter and lag) in the process.

Vsync's effect on input lag is another concern, because the GPU might have to hold onto a rendered frame for too long. For example, the GPU might buffer up to three fully rendered frames until the monitor is ready to draw a new on-screen frame. The lag trade-off can make Vsync unsuitable for shooters and other games that require precise, quick action. By perfectly matching the refresh rate of the GPU and monitor, FreeSync and G-SYNC do away with both screen tearing and Vsync's stutter and lag.

create FreeSync displays, and in total, there were 121 FreeSync compatible monitors. AMD expects that most all of the partners who built FreeSync monitors will create FreeSync 2-compatible options. But don't expect to see the market flood with as many FreeSync 2 monitors as you did with FreeSync monitors, because AMD will have strict standards for the minimum brightness, contrast, and color space. To make the cut, a monitor must be able to meet these standards while also delivering extremely low latency.

FreeSync

FreeSync's dynamic refresh rate is supported by most Radeon GPUs released in 2014 or after, which includes the Radeon R9 290 and R7 260X. Older Radeon GPUs, such as the HD 7000 and R9 280, support FreeSync for video playback and power-saving jobs, but these cards don't have a display controller that supports the transformative adaptive sync capabilities. GPUs based on AMD's new Polaris and upcoming Vega architecture, of course, support FreeSync. Best of all, AMD says that any FreeSync-compatible Radeon GPU will also support FreeSync 2.

As of December 2016, 20 display makers had partnered with AMD to

FreeSync's variable refresh rate capability is based on Adaptive Sync, which is a VESA (Video Electronics Standards Association) industry standard that was originally designed to support dynamic refresh rates over the DisplayPort interface. By using the existing DisplayPort protocol, AMD was able to reduce the complexity necessary to implement FreeSync into a display. NVIDIA's G-SYNC, by comparison, requires a chip inside the monitor that coordinates the refresh rate of the display. FreeSync's relative simplicity reduces cost and makes it easier for monitor manufacturers to support variable refresh rates.

Initially, FreeSync only worked over DisplayPort, but in 2016, AMD developed an extension of FreeSync to allow for variable refresh rates over HDMI. We've found that monitors typically only support FreeSync over either DisplayPort or HDMI. And unfortunately, not all monitor manufacturers have clear specifications about which display interface supports FreeSync, meaning you might have to dig through your display's manual a bit to discover which port supports variable refresh rates.



FreeSync & G-SYNC avoid screen tearing that can occur when Vsync is off.

There are some other notable caveats with FreeSync technology. To start, FreeSync monitors feature both a minimum and maximum variable refresh range, and the supported range varies widely by monitor. The variable refresh rate might be as little as 40Hz to 60Hz, or as wide as 30Hz to 144Hz. The maximum variable refresh range typically matches the maximum refresh range of the monitor, but the minimum could be as high as 48Hz.

When FreeSync was first released, the standard was criticized because it had no way to handle frame rates that dropped below a monitor's minimum variable refresh rate. In such cases, your system would revert back to Vsync, if you had it turned on, or introduce screen tearing, if Vsync was off. AMD's Crimson driver added LFC (low framerate compensation), which is an adaptive-sync algorithm to adjust the GPU's output and refresh rate for smooth motion when below the monitor's minimum refresh rate. There's a catch, though, because a FreeSync monitor must boast a maximum refresh rate that's 2.5 times (or more)



FreeSync works with many existing Radeon graphics cards, such as the R9 290 pictured here.

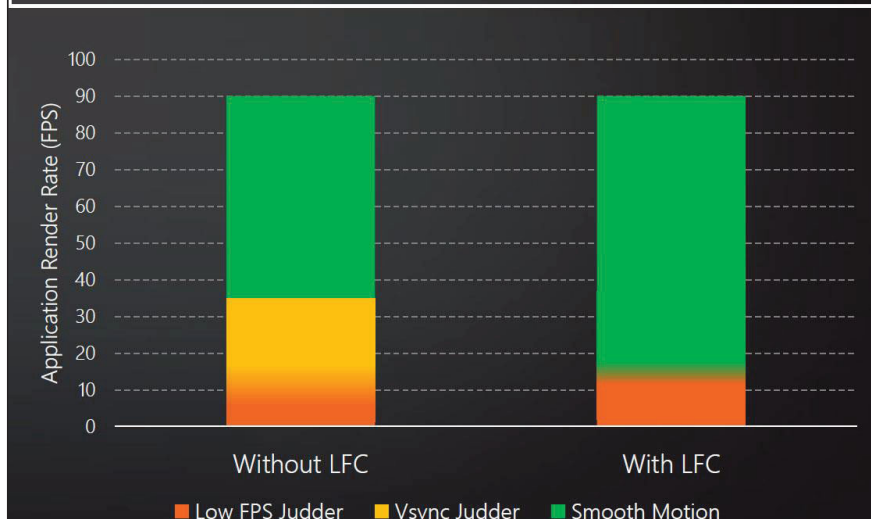
the monitor's minimum refresh rate to support LFC.

Again, the lack of strictly defined parameters requires you to research a monitor's FreeSync capabilities before

purchase. Fortunately, many of the FreeSync displays released in 2016 offer a much wider variable refresh range. If you often game at more than 75fps—or below 40fps—it'd be worth your time and effort to find a FreeSync monitor that supports the variable refresh rates you play at.

BEHAVIOR

VSync judder vs. low framerate judder with and without Low Framerate Compensation



AMD introduced Low Framerate Compensation to FreeSync with its Crimson driver.

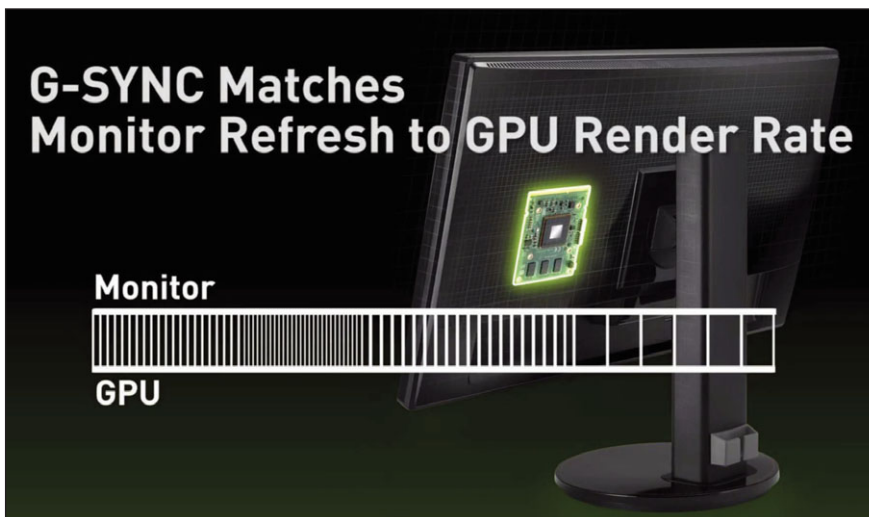
G-SYNC

NVIDIA was the first to develop adaptive-sync technology in 2013. G-SYNC is supported by GeForce GTX 650 Ti or greater GPUs, so it works even if your NVIDIA GPU is a few generations old. Even some of NVIDIA's mobile GPUs support G-SYNC, including the GeForce GTX 965M, 970M, 980M, and 10-Series notebook GPUs. With a dedicated GPU, you'll need to connect to a G-SYNC monitor via the DisplayPort cable.

On the monitor front, supported panels feature a G-SYNC chip that's in charge of the variable refresh rate. The approach helps NVIDIA to have a bit more control when using adaptive sync. NVIDIA indicates, for example, that G-SYNC displays don't have a minimum refresh rate limit and the maximum refresh rate matches up with the panel's



NVIDIA has supported G-SYNC on graphics cards since the advent of the GeForce GTX 650Ti.



G-SYNC monitors feature a G-SYNC module to coordinate GPU and monitor frame rates.

top refresh rate. The flip side is that G-SYNC monitors tend to be a bit more expensive than comparable FreeSync monitors, and there are fewer G-SYNC monitors on the market, due to the added complexity of the G-SYNC chip.

When G-SYNC was first released, NVIDIA received some complaints that gamers couldn't turn off G-SYNC for fast-paced shooters, such as CS:GO, that exceeded the

maximum refresh rate of the monitor. In this situation, G-SYNC would automatically revert to a Vsync mode to prevent screen tearing, and gamers didn't want Vsync's additional input lag. In 2015, NVIDIA updated G-SYNC to let you disable the technology at refresh rates above the monitor's maximum, though doing so will reintroduce the possibilities of screen tearing.

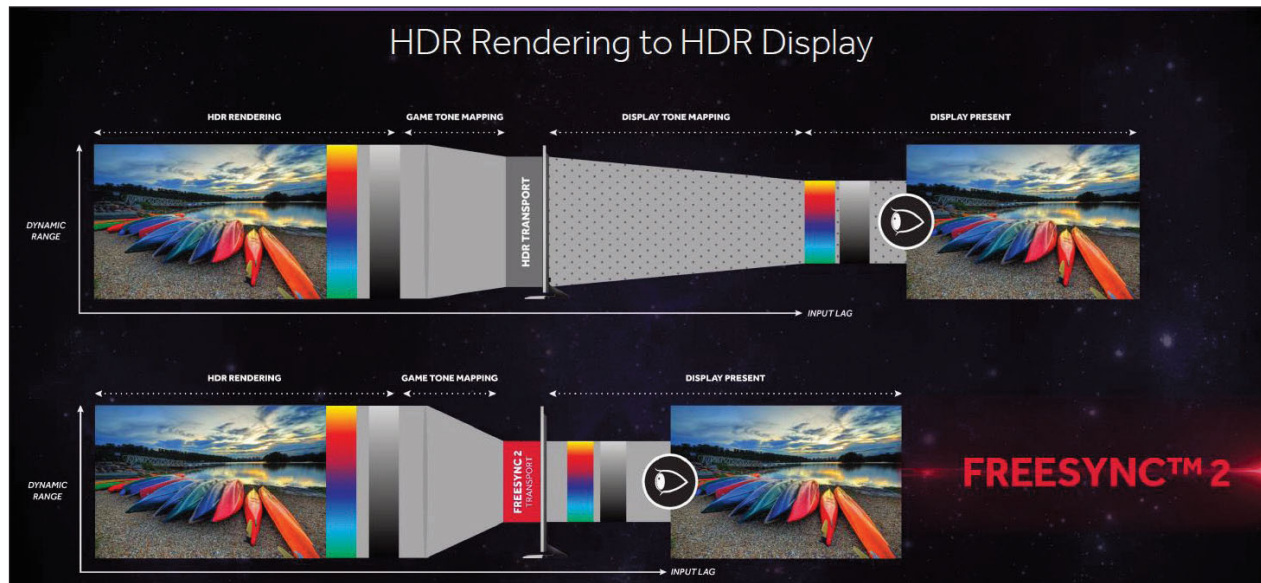
In 2016, the engineers at NVIDIA introduced another input latency-reducing feature called Fast Sync that, although not technically part G-SYNC, does complement the variable refresh rate technology. It's designed for the same group of people that wanted to turn off Vsync at high frame rates, yet still eliminates screen tearing. Fast Sync uses a triple buffer system, but the GPU renders the frames as if Vsync is off and grabs the most recent frame from the buffers. The resulting lag is only a little higher than with Vsync off and there's no screen tearing.

To further avoid ghosting and input latency, some G-SYNC displays support NVIDIA's ULMB (Ultra Low Motion Blur) mode, which strobes the backlight of a monitor to eliminate motion blur and reduce input latency. ULMB and G-SYNC can't function at the same time, though, so you'll need to choose which one to activate. Assuming ULMB is supported by the monitor, you can use the NVIDIA Control Panel to switch between the ULMB or G-SYNC display modes for specific games.

As you can see, NVIDIA's latest GPUs and G-SYNC monitors provide you with several different ways to optimize your gaming experience. A quick perusal of the market shows that the majority of G-SYNC monitors support refresh rates all the way up to 144Hz, which is ideal for enthusiasts with premium graphics cards. There are some FreeSync monitors that match up with the high-end G-SYNC panels, but many of the early FreeSync options lack the amenities of G-SYNC monitors.

FreeSync 2 & G-SYNC HDR

HDR is not yet common on PC displays—CES 2017 marked the debut of HDR monitors—but HDR was the “it” feature for HDTVs in 2016. HDR improves brightness, contrast, and color gamut, all of which help to make on-screen visuals more lifelike. At CES, we were treated to several demos that displayed content both on an HDR monitor and a conventional



FreeSync 2 puts the tone-mapping duties onto your GPU, rather than the monitor, to reduce input lag.

monitor. Colors on the standard panel were flat and washed out in comparison to the HDR displays, where we could clearly see more vibrant hues and deeper contrast.

HDR metadata and tone mapping, which allows for the expanded color saturation and contrast, forces the monitor to deal with a lot more data than what it sees with standard dynamic range content. Existing HDR formats (HDR 10 and Dolby Vision) work fine with Ultra Blu-ray movies and HDTVs, for example, because input lag isn't a concern. NVIDIA estimates that current HDR TVs produce at least 21 to 45ms of latency, while AMD indicates input lag could be as high as 100ms. Such input lag would kill the HDR experience for gamers. Both FreeSync 2 and G-SYNC HDR are designed to minimize input lag while supporting the tear-free adaptive-sync experience.

With FreeSync 2, AMD reworks the transport system for HDR. AMD indicates that FreeSync 2 takes the tone-mapping duties away from the display and moves it over to the GPU. The game engine, in turn, maps content for targeted brightness, contrast, and color values. AMD is providing a FreeSync 2 extension to game developers to make

it easier to incorporate HDR rendering into new games.

There are no concrete details about the exact brightness, contrast, and color gamut specifications a monitor must meet for the new FreeSync 2 and G-SYNC HDR standards. But we do know that any monitor to meet the respective standards must be approved and certified by AMD or NVIDIA. And because most current monitors are based on standard dynamic range specifications, it appears that monitor manufacturers will need to make some significant improvements to meet the respective HDR standards.

The ASUS ROG Swift PG27UQ is one of the first G-SYNC HDR displays, and it includes some features that most current premium displays can't match. For example, ASUS indicates that the PG27UQ supports a 1,000cd/m². Conventional PC monitors are designed to deliver between 200 and 300 cd/m². ASUS achieves this through the use of quantum-dot technology and a backlight that can be selectively controlled over 384 zones. According to ASUS, breaking down the backlight to individual zones allows the HDR transmission to selectively dim zones and maximize contrast, while the

quantum-dot nanoparticles are able to produce a wider range of colors.

AMD hasn't officially certified any displays for FreeSync 2, but the company's Senior Manager of Global Technology Marketing, Antal Tungler, tells us "several displays are in the certification pipeline now." Again, there's no definitive timeline on when FreeSync 2 monitors will be available, but we expect some to see some announcements this year. One thing we can say for certain is that all FreeSync 2 monitors will support LFC, and AMD expects the monitors to provide twice the perceivable brightness and color volume over standard RGB panels.

A Game Changer

FreeSync and G-SYNC displays are readily available to produce exceptionally smooth, fluid gaming visuals, when paired with a compatible graphics card. FreeSync 2 and G-SYNC HDR are the next step toward perfect pixels, but it will likely be a while before the HDR standards are widely supported by monitors and games. Even so, it's nice to see AMD and NVIDIA get ahead of the curve with HDR, and the backing of Team Red and Team Green should help to move the needle with monitor manufacturers. ■

CES 2017

Kaby Lake, Ryzen & Friends



GIGABYTE showed off the Mod2Win-winning Project Triptych this year at CES.

GIGABYTE & AORUS

GIGABYTE announced a lot of products at CES, including some interesting cases and a gaming chair, but the company's biggest focus was the expansion of its AORUS brand. Previously known primarily for notebooks, you'll now see other premium gaming hardware under the AORUS brand, including motherboards and GPUs. The motherboards all feature RGB LEDs and a number of other gamer-centric features. We also saw a number of excellent mods in the suite; one of our favorites was Project Triptych, which took first place in GIGABYTE's 30th Anniversary Mod2Win Challenge.

2017 promises to be an exciting year in PC technology if this year's Consumer Electronics Show is any indication. Many manufacturers we visited were touting new motherboards, systems, and high-end laptops based on Intel's new Kaby Lake chips and the Z270 chipset. Best of all, it looks like AMD is back in the enthusiast game

with Ryzen processors and the AM4 chipset on the horizon. Power users can also look forward to the continued growth of VR, including new VR systems, better hardware support, and more innovative applications. Big trends from last year, such as RGB LEDs, 4K displays, and gaming peripherals, are also on an upward trajectory.



MSI

MSI is revamping much of its sub-\$2,000 gaming laptop line with 7th Generation Intel Core processors and NVIDIA GeForce GTX 1050 Ti and 1050 GPUs. New models include the GE72MVR, GE62MVR, GE72VR, and GE62VR. On the high end, many MSI GT and GS series laptops now support Hi-Res Audio to deliver the finest audio quality. The GT83VR, for example, features a SABRE HiFi DAC and supports 32-bit/384KHz sampling rates, while several of the GT73-, GS73-, and GS63-series models



support 24-bit/192KHz sampling rates. MSI also showcased a host of Z270 motherboards and gaming systems outfitted with 7th Generation Intel Core processors.

AMD

AMD's CES suite featured a wide array of prototype motherboards and systems with AMD Ryzen processors. We don't have full processor details yet, but the new AM4 chipset is expected

to support dual-channel DDR4 memory, PCIe, NVMe SSDs, USB 3.1 storage, and PCIe 3.0 graphics. The cutting-edge features will help move AMD back into the contention for enthusiast builds.

Patriot

There will be several new Patriot Viper peripherals coming out this year, including gaming mice, headsets, and keyboards. The Viper V570 is a laser gaming mouse designed with both FPS and MMO gamers in mind. It features an Avago 9800 laser sensor that can track at up to 12,000dpi, as well as 13 programmable macro buttons—five of

which are side buttons that you can quickly access with your thumb. Of the new keyboards, we like the Viper V770 with linear mechanical switches (Kailh Red) that actuate at 2mm for lightning-quick response.

ENERMAX

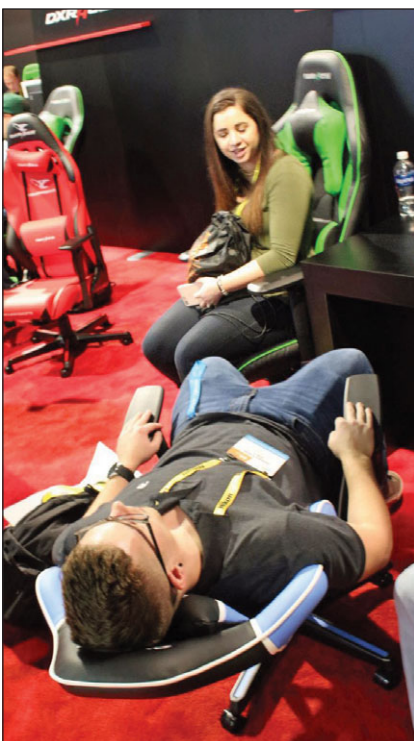
In March, ENERMAX will release the NEOChanger, which is a DIY liquid-cooling pump and reservoir combo kit with RGB LEDs. Reservoirs are available in three heights (3.94 inch, 5.9 inch, and 7.87 inch), and ENERMAX includes a remote to adjust the LED color, lighting effect, and pump speed. The company was



also showing off some attractive new cases and powerful PSUs.

DXRacer

CES can be an exhausting experience, and DXRacer's booth was a great place to kick back and relax. The chair experts had a variety of their super-comfortable thrones for everyone to try out, including the newly released Elite series and Tank series.



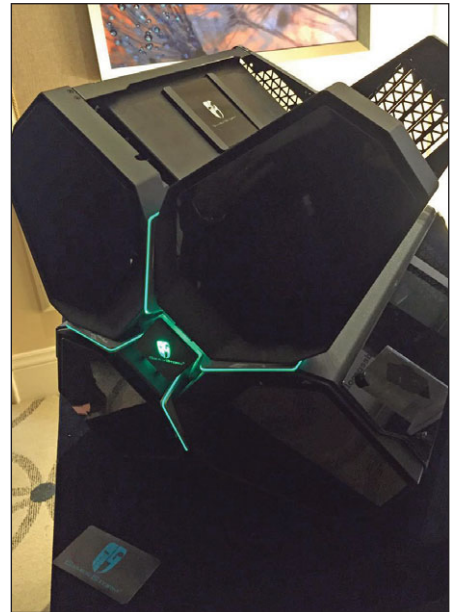
OCZ

Sometime this summer, OCZ will introduce PCIe SSDs made with Toshiba's BiCS 3D NAND. The prototype seen here (a 128GB drive) impressively shows off just how small and compact 3D NAND can be. OCZ tells us that the speedy SSDs will be available in typical M.2 form factors.



Deepcool

Deepcool's Quadstellar builds upon the success of the Tristellar with four compartments and more space for the motherboard and GPUs. The Tristellar,



for example, limited you to a Mini-ITX motherboard and one GPU. The prototype we saw supports a full-sized ATX motherboard and up to three graphics cards.

Alphacool

To create smoother LED lighting inside your case, Alphacool plans on releasing LED light strips. The Eislicht will be available in a few different sizes, lengths, and colors to match your build. Alphacool also has plans for new waterblocks, paintable radiators (with a white exterior that makes them easy to paint), and an external AIO radiator.



Mods

Shui-Shen Project. We could go on and on about all the excellent detail work in Mike Petereyn's Shui-Shen Project, but what will really blow you away is the custom distribution panel with milled-out water channels. That's right, the front panel window also serves as part of the liquid-cooling loop. Check out the detail on the 3D-printed GPU shroud, too.



PC Of Souls. If you think this rig looks good here, you should see how the UV-reactive elements of the case glow in the dark. Marc Molella's PC Of Souls is an Avatar-themed PC featuring the movie's iconic spirits and tree of souls that glow in dark. RGB illumination throughout the mod allows the PC Of Souls to have a constantly changing glow. ■



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Minerva

This month, as we have at *CPU* for many years now, we had to choose an overall winning mod from among the winners of all of the mod contests we've judged at LANFest LAN party events around the country in 2016. The competition was tough, and our top three contestants this time around wound up including one repeat Mad Reader Mod winner (the incomparable Brian "Boddaker" Carter) and two modders who've never yet won a spot in the feature.

Our final tallies showed the decision to be unanimous: This year's winner was Christian "hashtag pound sign" Frost's steampunk-themed mod, Minerva. Frost got a lot of help on this project from his girlfriend, Pixie Williams, and the two proudly showed off their work in September at CPULAN 2016 in Lincoln, Neb., where it was a similarly unanimous winner.

Goddess

Frost provides the briefest of explanations as to his mod's name, saying only that he and Williams "felt that the name captured the whole artistic side of the machine." Fair enough, but in Roman mythology, Minerva was the goddess of wisdom and arts, among other things. This also fits the pair's M.O.

"It's really hard to say exactly where the inspiration comes from," Frost says. "In some cases it will be a visual incentive, sometimes a thought or feeling. My girlfriend and I have always been very artistic, so the inspiration mostly comes from within."

Unlike Minerva the goddess, Minerva the mod was not born fully grown. Frost says he spent roughly three weeks working

on the project, during which he worked with wood, copper, old gauges, antique parts, and gears, along with potentiometers to control the fans and old switches to control the LED lighting.

"I built this system because I love building, creating, and modding PCs," Frost says. "I don't like to adhere to any one doctrine. By that, I mean that I don't follow what is traditionally done. For example, the traditional square case. For my girlfriend and me, modding PCs is just another form of art, and it is all about getting that artistic vision onto a canvas. In this case, it was a steampunk canvas. In addition, I just wanted to see if I could actually do everything my mind's eye was seeing and for me the more difficult it is to accomplish, the more driven and determined I am to make it all work. Yes, the PC does fill a particular purpose; it is my daily PC, but it has also become a great conversation piece and, for us, artistically pleasing to look at."

It's safe to say they're not alone; everyone who has seen this piece has been blown away by it.

"There are a lot of parts on this machine that are truly unique—one of a kind," Frost says. "We avidly shop antique stores for unique pieces to collect so we can incorporate a lot of these rare finds into our projects. Finding old or rare items that are left behind in old, abandoned farms or houses has become a beneficial hobby of sorts."

The "Steam" In "Steampunk"

As you can tell just by looking, this rig took a lot of hard work to complete. Frost rewired his power supply so that



he could have both AC and DC voltage for the steampunk lights and still only have one wire that plugs into the wall. He scavenged many of the gears and other small mechanical parts from broken watches, some of which had then been incorporated into jewelry and other items.

Frost delidded his Core i7-3770K and left the integrated heat spreader off so that he could implement a more direct cooling solution; doing this required him in turn to mod the CPU socket to adjust for the proper pressure so that the CPU would work properly. He also disabled his graphics card's overcurrent protection so that he could push GPU overlocks a bit.

In addition to his 3770K, Minerva's components include a GIGABYTE motherboard, 32GB of PNY DDR3 memory, a GeForce GTX TITAN X graphics card, a 900-watt Antec power supply, a pair of 1TB SSDs in RAID configuration to run Windows 10, a pair of 256GB SSDs in RAID running Windows 7, and a 1TB hard drive for storage. The system's cooling system mostly consists of XSPC waterblocks and custom radiators.

Next Up In The Pantheon

Frost tells us that he's working on his next build already, but is characteristically mum on the details. "I hesitate to say what it is at the moment, because we are planning on bringing it to a LANFest event soon," he says.

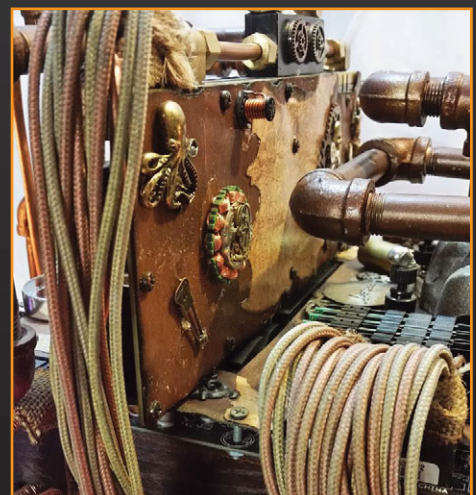
Fair enough, Mr. Frost. ■

We Want Your Mod

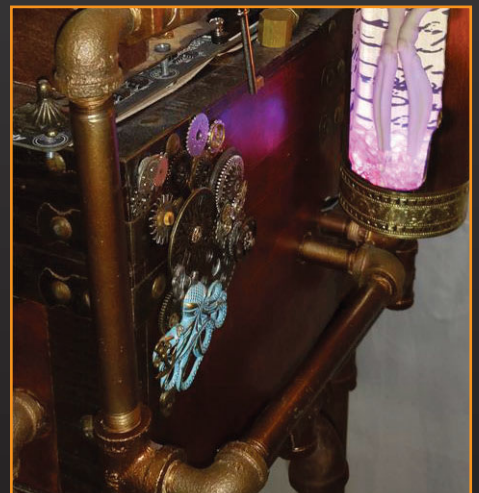
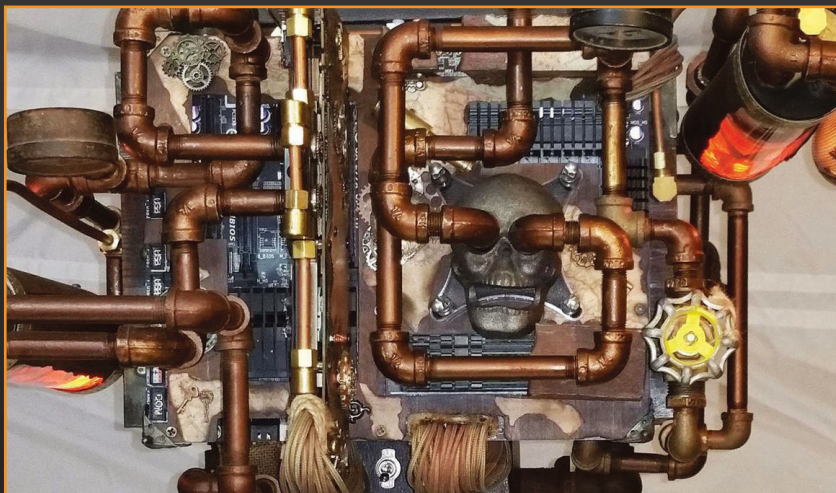
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Laptop Leadership

MSI's GT83VR TITAN SLI Sets The Bar For Portable Power

Utter the words “desktop replacement notebook” to any power user who’s been around the block once or twice, and he’ll immediately know what you’re talking about. These mighty mobiles focus more on might and less on mobile, as they’re built to have all the horsepower of a desktop system while maintaining portability (technically). You wouldn’t take a desktop replacement notebook to Starbucks to work on your Tumblr page, but they’ll fit right in at a LAN party.

Because mobile components advance almost in lockstep with their desktop counterparts, DTR notebook manufacturers must constantly figure out new ways to pack the latest and greatest hardware into roughly the same physical shell. After all, the mammoth coolers bolted onto today’s graphics cards and CPUs don’t exactly fit inside a laptop. It’s a challenge that has existed for as long as DTRs have been around.

Recently, MSI has led the DTR charge, releasing a slew of new units you could easily mistake for high-end desktop PCs based only on their specs. Among this squadron of high-flying laptops is the GT83VR TITAN SLI, which is armed with an array of advanced weaponry. In order for this imposing DTR to take flight, MSI called in its top engineers and launched a skunkworks project of epic proportions.

Lofty Ambitions

From the beginning, MSI set out to create a laptop that would excel in a variety of roles, not just gaming. Lenny Tang, MSI associate marketing manager, explains that the “VR” in “GT83VR TITAN SLI” means the DTR is not only capable of playing virtual reality games but designing them, as well. According to Tang, MSI wanted to give VR developers a system that could render 3D models,



Boasting a new 7th Generation Intel Core i7 CPU and two—count ‘em, two—NVIDIA GeForce GTX 1080 GPUs in SLI, it should be obvious to enthusiasts that MSI’s GT83VR TITAN SLI will crush any benchmark, game, or other high-intensity task you put in front of it.

handle game designs, and run any other relevant programs.

“This laptop could function as a mobile workstation or desktop replacement when hooked up to multiple external 4K monitors,” he adds.

MSI’s goal of making an insanely strong laptop for enthusiasts, gamers, and professionals is realized in a number of features included in the GT83VR TITAN SLI. Its 18.4-inch screen is a 94% NTSC panel, which helps accurately reproduce colors on screen, a vital capability for visual artists, graphic designers, and others. The laptop also includes a Thunderbolt 3 port, which is quickly becoming the preferred interface among creative professionals. MSI also deployed its proprietary True Color Technology in the GT83VR TITAN

SLI, further cementing the DTR as a true workhorse for virtually anyone who uses it.

Core Components

MSI has assembled a murderers’ row of components for the GT83VR TITAN SLI. Although mobile variants are used in the case of the CPU and GPUs, these chips are within striking distance of their corresponding desktop components. For example, in the case of the GT83VR TITAN SLI’s twin GTX 1080 GPUs, Tang notes, “the [performance] difference between true desktop and mobile is less than 5%.”

The brains of the operation is Intel’s brand-new Core i7-7920HQ, which is essentially the company’s most powerful mobile processor. Part of the Kaby Lake

crew, the Core i7-7920HQ is a quad-core chip with Hyper-Threading, so it can handle up to eight instructions at once. The processor's base operating frequency is 3.1GHz, which trails Intel's leading Kaby Lake desktop CPU, the Core i7-7700K, by 1.1GHz. One key reason behind the difference in base operating frequency is 7920HQ's lean TDP—only 45W. By comparison, the 7700K can draw up to 91W. Regardless, expect the 7920HQ and its multithreaded prowess to yield excellent performance.

Arguably the GT83VR TITAN SLI's centerpiece, its two GeForce GTX 1080 GPUs should strike fear into the hearts of pixels everywhere. Based on NVIDIA's Pascal architecture, the GTX 1080s found in the GT83VR TITAN SLI are almost indistinguishable from the GTX 1080 desktop card. Both feature an 8GB GDDR5X frame buffer that uses a 256-bit memory bus. The memory hums along at 10Gbps, which adds up to 320GBps of memory bandwidth. NVIDIA dials back the base frequency of the mobile GTX 1080, but only slightly. Instead of the 1,607MHz base clock of the desktop GTX 1080, the mobile GTX 1080's base frequency is set to 1,556MHz, only a 3.2% difference. Granted, similar speeds and feeds don't

always directly translate to real-world, in-game performance, but like the 7920HQ, the two GTX 1080s in the GT83VR TITAN SLI should be able to take on any game, VR or otherwise. MSI also took steps to ensure the GPUs were well fed. As it turns out, supplying adequate power to the GTX 1080 tandem was MSI's highest hurdle to clear.

"The biggest design challenge was powering the two GPUs, which resulted in two power bricks, powering one GPU each," Tang says.

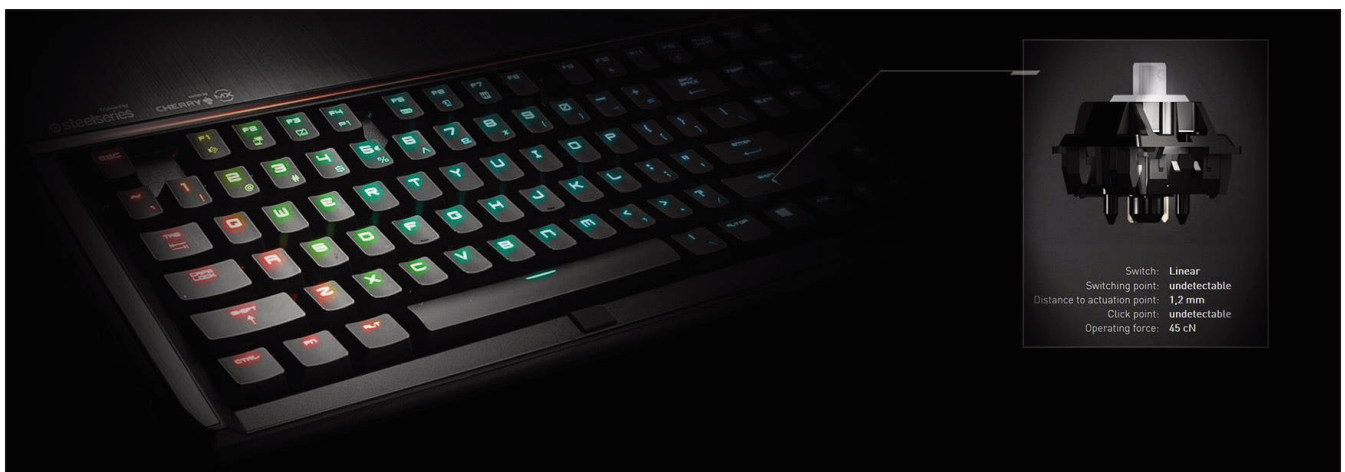
MSI filled the GT83VR TITAN SLI with other components befitting its status as the company's flagship laptop. It's stuffed with 64GB of DDR4-2400 system memory, which should be enough to make any regular user of Adobe Creative Cloud or Sony VEGAS salivate. This DTR's storage subsystem is similarly well-appointed. Recognizing the dominance of PCIe solid-state drives, MSI has doubled down with a pair of 512GB PCIe SSDs and yoked them together with its Super RAID 4 technology for even greater throughput. For bulk storage, the laptop contains a 1TB 7,200rpm HDD.

For networking, MSI turned to Killer Networking. Specifically, the GT83VR TITAN SLI's Ethernet controller is the

BIG BAD LAPTOP

MSI GT83VR TITAN SLI Specs

CPU	Intel Core i7-7920HQ
Chipset	Intel CM238
GPU	2x NVIDIA GeForce GTX 1080 8GB GDDR5X
RAM	64GB DDR4-2400
Storage	2 x 512GB PCIe SSD (Super RAID 4), 1TB 7,200RPM HDD
Display size	18.4 inches (IPS)
Display resolution	1,920 x 1,080 (MSI True Color Technology)
Keyboard	88-key SteelSeries (Cherry MX Speed Silver keyswitches)
Networking	Killer E2500 (LAN), Killer N1535 (WLAN)
Ports	5 x USB 3.0, 1 x Thunderbolt 3, 1 x HDMI, 1x mini DP, audio I/O
Dimensions	2.52 x 16.85 x 12.36 inches (HxWxD)
Weight	13.13lbs.
Warranty	1 year



Most laptops aren't known for their keyboards, but the MSI GT83VR TITAN SLI isn't most laptops. For the system's keyboard, MSI turned to SteelSeries to come up with something grand, and the Danish manufacturer didn't disappoint. The GT83VR TITAN SLI features Cherry MX Speed Silver mechanical keyswitches, so gaming on the laptop should feel virtually identical to using a mechanical keyboard with a desktop PC.

Killer E2500, which aims to crush latency with its Lag and Latency Reduction Technology. The 802.11ac adapter is another Killer chip, the Killer N1535.

Compared to previous generations, Tang says the Killer E2500 “has better program prioritization over previous versions and effectively uses the Ethernet controller to optimize bandwidth. Its newest Advanced Stream Detect 2.0 technology will prioritize games and real-time communication.”

Cool Your Jets

In addition to supplying the GT83VR TITAN SLI with enough juice for its components, MSI had to devise a cooler that could keep the laptop’s hottest (as in, literally) components in check. The solution was the Cooler Boost TITAN. Although it was based on the cooler inside MSI’s last-gen GT laptops, Tang says the new cooler went through several revisions before being completed.

“The biggest gripe we heard from users was that the GT series was overheating and throttling,” he says. “Our engineers know that there are only so many ways of

diverting heat effectively and efficiently, especially on a mobile chassis.”

First, MSI beefed up the Cooler Boost TITAN increasing the number of heatpipes to 15. The company also redesigned the cooler’s fin structure in order to increase its surface area and maximize airflow. The cooling fans also received an overhaul. MSI made the fan blades wider and thinner, which made room to increase the number of blades. Between the CPU and GPU fans, 52 blades work to cool the chips. According to Tang, the end result is a 30% increase in airflow.

Mechanical In A Mobile

From an input device standpoint, one clear advantage desktop PCs have traditionally enjoyed over laptops is the option to use a keyboard with mechanical keyswitches. From gaming to everyday typing, mechanical keyboards tend to be far superior to the low-quality keyboards typically found in laptops. Again, MSI was determined to build a laptop to rival any desktop, so addressing one of the least

frequently addressed aspects on laptops was a top priority.

With an assist from the gaming peripheral experts at SteelSeries, MSI equipped the GT83VR TITAN SLI with Cherry MX Speed Silver keyswitches. A linear switch developed with gaming in mind, the MX Speed Silvers have a very short actuation distance, a mere 1.2mm. The total travel distance of 3.4mm is similarly short. The switches only require 45cN of force to actuate, the same as Cherry’s MX Reds.

“When designing the keyboard, our engineers studied the optimal wrist angle and length where it would cause the least fatigue over time,” Tang says. “When a standard wrist rest is used with the GT83VR, the keyboard on the laptop is actually very comfortable to type on.”

Big Picture

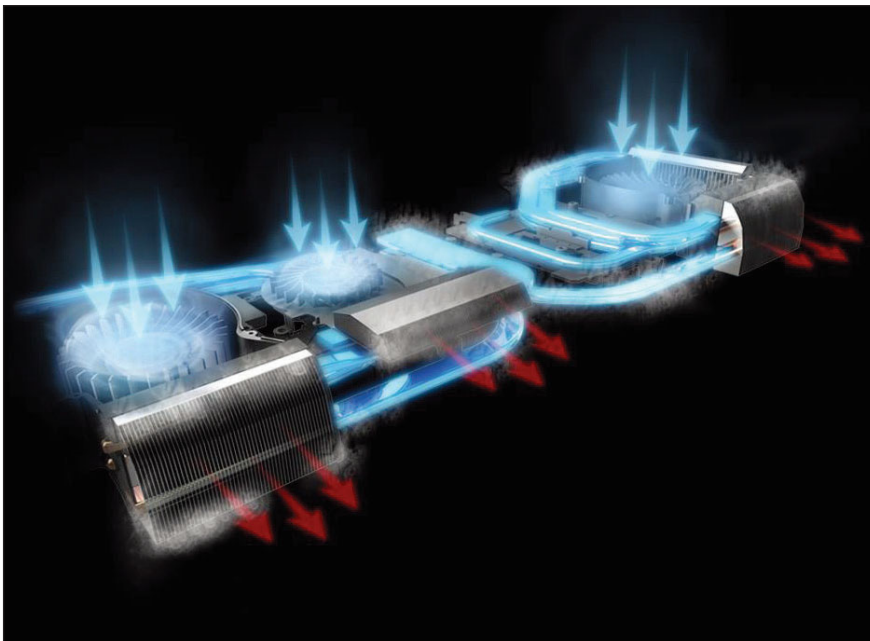
A laptop can have all the latest hardware and still fall short if it has an inferior display. Gamers need a clear picture of the action, but a high-quality screen is even more important for professionals whose jobs depend on things like on-point color reproduction. To serve both of these audiences, MSI gave the GT83VR TITAN SLI an IPS panel and complemented it with homegrown software.

The benefits are clear. Compared to TN panels, the GT83VR TITAN SLI’s panel offers 40% better contrast and 20% increased brightness. As mentioned, the panel boasts a 94% NTSC color gamut.

By using MSI True Color Technology, users can configure the GT83VR TITAN SLI’s display precisely to what they need. For example, Gamer mode boosts brightness, while Movie mode tweaks contrast for a proper cinematic experience. For professionals, True Color Technology can set the display to 100% of the sRGB color gamut.

Super-Size Me

At 13.13 pounds, MSI’s GT83VR TITAN SLI is unapologetically large. Considering all of its cutting-edge hardware, though, it’s also unapologetically awesome. If you want to take as much computing muscle with you as possible, this is how you do it. ■



Using a pair of NVIDIA GeForce GTX 1080 GPUs in a laptop is bound to present thermal challenges, so MSI’s engineers went to work devising a cooler capable of dealing with all the heat. The end result is the Cooler Boost TITAN, which has a whopping 15 heatpipes to help wick away heat from the laptop’s CPU and GPUs.

DS 230

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AORUS RISING

This Is What An Enthusiast Motherboard Looks Like



If you're looking for the perfect platform for your Kaby Lake or Skylake processor, look no further.

Last month we introduced you to the new Intel 200 Series chipset, formerly codenamed Union Point, and our first look at a motherboard outfitted with the Z270 variant –built for enthusiast class components– came in the form of the AORUS GA-Z270X-Gaming 5. We liked what we saw from that board, but we knew there was another motherboard waiting in the wings that would really knock our socks off. If you think of Intel's Z270 PCH as a blank canvas, then the topic of this month's Whitepaper is what you get when GIGABYTE sets out to paint its Sistine Chapel.

A Growing Brand

AORUS, as a premium gaming brand, has been around for a few years. We know it as home to GIGABYTE's enthusiast-grade laptops, mice, and keyboards, but most recently it has been expanded to include a cross-section of graphics cards and motherboards that are designed to appeal to users looking for a little extra from their components in terms of features, aesthetics, and performance. GIGABYTE's Ultra Durable, G1 Gaming, and SOC Force product lines aren't going anywhere, just skooching over to make room for GIGABYTE's fist-pumping raptor. If you listen real close,

you can almost hear that logo screeching a very high-pitched "Let's do this!"

Redefining The Flagship

When it comes to single-digit numbers, nothing beats a 9, which is why the highest-end AORUS motherboard in the lineup gets that number for a suffix. The AORUS GA-Z270X-Gaming 9 (\$499.99) is packed with so many enthusiast features that they're listed on the box in font sizes typically reserved for legal disclaimers. But seriously, this motherboard offers superior overclocking, insanely fast storage, ear-pleasing customizable premium audio,

support for multiple GPUs in a variety of configurations, a crazy amount of high-speed I/O devices, and a top-rate LED lighting system that lets you decide whether to keep things low-key or go full-on Pink Floyd Laser Light Show. In GIGABYTE's own words, "we set out to create a premium board that gave our customers the ability to adapt and customize every aspect of its operation. From RGB Fusion software, to Smart Fan 5, headers galore, and a robust I/O, we feel that anyone looking to build a system that is uniquely their own will want to give the AORUS Gaming 9 serious consideration." We couldn't agree more.

Advanced Tech Comes Standard

This motherboard is built to support 6th and 7th Generation LGA 1151 Intel Core Processors, better known as Skylake and Kaby Lake. When you opt for an enthusiast motherboard, the complexity and capabilities of the VRM usually get a significant upgrade, and the AORUS GA-Z270X-Gaming 9 is no exception. The VRM hugging the top and left side of this motherboard's CPU socket consists of an incredibly deep 22-phase power delivery system, comprising 4th generation IR digital power controllers and 3rd generation PowIRstage ICs,



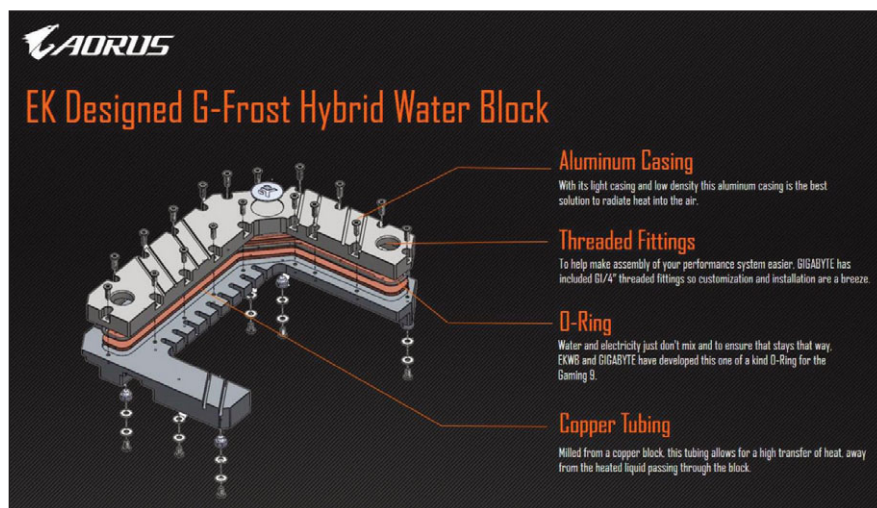
LED lighting on the AORUS Gaming 9 is only as bright and colorful as you want it to be.

with Isense technology. This portion of the motherboard is responsible for precise current sensing and thermal load regulation and distribution. According to GIGABYTE, "Clean efficient power delivery is important in any high-end system. Voltage is dynamic, spikes or drops can cause serious problems at worst or puzzling and/or annoying issues at best." But beyond preventing power delivery issues, such a hearty VRM helps contribute to a longer motherboard lifespan, consistent reliability, more stable

overclocking results, and cooler running temperatures.

Cool Under The Collar

When your processor is under load, the VRM will heat up, which is why GIGABYTE enlisted the expertise of one of the world's foremost experts in liquid cooling, EKWB, to help design a solution that can dissipate that heat in the most efficient way possible. The result is the G-Frost Hybrid waterblock, which is built on top of a C-shaped block of aluminum straddling the processor socket. If you choose to forego liquid cooling, the low-density lightweight heatsink base with a copper core will adequately keep your VRM well within safe operating temperatures. But that copper core is actually a precision-milled liquid channel topped with a smoked black translucent acrylic cover and sealed with a custom-fitted O-ring. The G-Frost Hybrid features a pair of G1/4-inch threaded fittings, making it easy to incorporate the unique heatsink/waterblock into your custom loop. If you do opt to go that route, you'll get significantly better cooling performance and in turn decrease the chances that even a stout overclock will result in scenarios where thermal throttling occurs. Keeping this portion of your board cool can also ensure your processor lives a long full



Yes, this motherboard comes with a waterblock. Yes, the water block helps lower your system temps even if you opt to go the air-cooling route.



Some people say they can tell everything they need to know about a motherboard by the rear I/O. On the AORUS Gaming 9, the I/O is just the tip of the iceberg.

life. GIGABYTE tells us that this is just one more area where the design of the AORUS Gaming 9 was dictated by a desire to ensure users have the flexibility to build their systems without limits.

Traditionally, regardless of whether you choose air cooling or liquid cooling, you need to plug fans, and possibly a pump or two, into the appropriate headers on the motherboard. As we all know, not every cooling device works well with PWM (pulse width modulation) control, and pumps perform best within a rather strict set of minimum and maximum rpm settings. On the AORUS Gaming 9, however, you can plug your CPU fan(s), case fans, pump(s), or radiator fans into a series of hybrid fan headers, which let the motherboard automatically enable the appropriate running mode, either PWM or voltage. Each hybrid fan header on this motherboard supports up to 2 amps with built-in overcurrent protection, which is particularly useful for enthusiast-grade high-current fans. But the fan headers don't presume to know everything; if you have other ideas about how best to run your cooling subsystem (perhaps you prefer to create custom fan curves for each component?), you can do that using GIGABYTE's intuitive Smart Fan 5 software. All told, there are seven internal temperature sensors, two external temperature sensors, and eight fan/water pump connectors, all with GIGABYTE's Hybrid Fan technology baked in.

DRAM, Unlimited

There are four memory slots to the right side of the CPU socket and these support dual-channel Non-ECC Unbuffered DDR4 memory, with XMP-profile-based overlocks as high as DDR4-4133, and beyond. Each DIMM slot can handle a 16GB module, for a total of up to 64GB of system memory. GIGABYTE has also validated more than 1,000 kits that span almost the entirety of DDR4 vendors, ensuring your memory

has the best chance of working optimally out of the box.

Graphics Galore

They didn't put "Gaming" in this motherboard's name for nothing. This is the only AORUS board available that supports up to 4-way SLI and CrossFire, thanks to a 32 lane boost that comes courtesy of PLX Technology's PEX8747 chip, a PCIe 3.0 switching device that provides users with the ultimate flexibility in setting up their system. If you're running 2-way SLI or CrossFire, the first and third PCIe slots will take the 16 lanes from the processor and double it so that both cards run on 16 lanes each. 3-way multi-GPU setups let one card run at x16 and the remaining two at x8 and 4-way multi-GPU setups will let all four cards run at x8 speeds. The chip is specifically optimized for high-resolution graphics applications and supports packet cut-through, with a maximum latency of 100ns, to all but eliminate the input lag that can result from running a multi-GPU rig.

Now, there are those of you who will point out that even a pair of the fastest



It's bright and colorful, but don't mistake the AORUS Gaming 9 for a toy, this thing runs like a supercar.



Yep, the kitchen sink's in there too. Probably.

graphics cards available today running on PCIe 3.0 slots hamstrung at x8 speeds won't be perceptibly slower than those two graphics cards running on slots with access to 16 lanes each. But GIGABYTE isn't thinking about the graphics cards you'll plug in today, they've got their sights on the card you'll plug in next year, or the year after that. "Future proofing is relative, but yes, the PLX chip at 16/16 is the closest to 'future proof' as you can get!"

We're also happy to report that a system built with the AORUS Gaming 9 can detect the currently populated PEG slot(s), so you're not stuck using the topmost slot if something goes wrong or if you just want to move the card to an expansion slot further down the board.

The Ultimate DIY Troubleshooter

If you're reading the pages of CPU, chances are good that you're the kind of person who likes to build your own PC, and that DIY mentality almost always extends to fixing any problems that crop up. To help you in those inevitable endeavors, the AORUS Gaming 9 features a series of debug LEDs on

the top-right corner of the board that, during the boot process, light up as the component (CPU, memory, GPU, and storage drive) is checked. When the device passes the check, the light goes out. If there is a problem, however, the culprit's LED remains lit, giving you a quick place to check first, so you can get back up and running quickly. Additionally, there's a 4-digit POST code display that provides even more clues to help you troubleshoot. Once the OS has booted, you can configure it to display system voltages or temperatures.

Super Speedy Storage

As we wait for Intel's Optane Technology to deliver products we can actually buy, there's still tons of ways to supercharge the storage devices on the AORUS Gaming 9 motherboard. There are two native U.2 (Gen 3 x4) connectors onboard, and you can use an M.2 to U.2 converter to plug in a third NVMe device, and run all three 32Gbps devices in RAID 0 for insanely fast 3,525MBps sequential read and 2,841MBps sequential write speeds. There's also a

Thunderbolt 3 controller onboard that you can tap into via the USB Type-C port for up to 40Gbps bandwidth, support for daisy-chaining up to six devices, and a 4K resolution display at 60fps.

Tough Enough For Anything

All the amazing technology in the world isn't worth bupkis if your system can't even survive a trip to a LAN party. That's why the AORUS Gaming 9 features a series of steel-reinforced PCIe Armor slots and Ultra Durable Memory Armor slots. These keep the board from flexing during install, and heavy graphics cards from coming loose or shearing-off during transport. The motherboard's many resistors also feature an Anti-Sulfur protective coating, which keeps the Nickel layer pristine and highly conductive for the life of the board. Add this to the Durable Black solid capacitors, Nichicon fine gold and WIMA audio capacitors, 2x copper core PCB, the gold-plated CPU socket pins, and you know the AORUS Gaming 9 can handle whatever you put it through without missing a beat.

A Sound Choice

We've written at length about GIGABYTE's upgradable OP-AMPs, but the AORUS takes it a step further, letting you swap out and upgrade three different chips, one each for the left and right channels that correspond to the rear I/O, and a third that corresponds to the front audio jack. Creative Sound Blaster ZxRi relies on a quad-core audio processor and a 127dB Burr-Brown DAC to deliver discreet-quality sound, in movies, games, and a variety of steaming video options.

The Complete Package

The AORUS Gaming 9 represents a winning combination of the latest technologies, fastest protocols, and limitless potential that make building your own PC such a fun and rewarding experience. This is one of the rare motherboards that truly won't hold you back. ■

Modder Q&A: Adam Owen

DOHCDragon On QuakeCon, Builds & More

Adam "DOHCDragon" Owen's work has appeared in *CPU*'s "Mad Reader Mod" feature on three occasions, all of them in conjunction with our coverage of the QuakeCon mod contest. In the October 2013 issue, we enjoyed his NES Coffee Table Computer, we loved his 3D Printed Tiger Tank Computer in the September 2014 issue, and the September 2015 issue featured his Peace, Love and Rockets mod.

Q : You told us a couple years ago that your goal was to build a new system each year for QuakeCon. Have you managed to keep up with that pace?

AO : I have, the only exception was this last year. I was in the 24 Hours of Le Mods event with a fellow modder and friend, Mike "MikeKnight" Long. I did help a friend of mine (Rob "Whiskers" Wilson) build a mod, though. It's based on Commander Keen's ship, Bean-with-Bacon Megarocket.

Q : How many QuakeCons have you been to now, and how did you get started attending?

AO : I have been to every QuakeCon starting in 2006. A friend and fellow modder, Mike "whiterice" Walt talked me into going, and I have been addicted ever since.

Q : Two of your three QuakeCon mods that we've covered won the contest's Scratch Build category; do you favor scratch builds over case mods in general, or did it just work out that way, and why?

AO : It definitely just worked out that way. I have always preferred case mods, but I wanted to try my hand at scratch builds, which is why I created the NES controller. The idea of the tank followed and the rest, as they say, is history.

Q : Speaking of the 3D Printed Tiger Tank Computer, that was entirely



Owen and his favorite mod project to date, The Behemoth.

constructed of 3D-printed parts (except for the PC components, of course), and Peace, Love and Rockets had quite a bit of 3D-printed parts, as well. What would you say is the best thing about 3D printing from a modder's perspective?

AO : 3D printing is still not easy. When I built the tiger tank, I was overwhelmed and forced myself to learn the art of 3D printing. That being said, once you have it down, it is a valuable tool. It

allows you to design and test things in a 3D environment and then print them to make them a reality. I don't think it is necessary to use 3D printing in case mods, in fact I have seen some amazing computers made without it. But it is a tool I will use from now on, and I believe the work I have done shows some of the things it brings to the table.

Q : The NES Coffee Table Computer was awesome, just from an aesthetic standpoint, but the fact that you could



Owen and Mike "MikeKnight" Long competed in the Modders-Inc GeForce Garage "24hr of Le Mods" event at QuakeCon 2016.

actually play Nintendo with it was just amazing. Likewise, the Tiger Tank Computer was drivable and had a working camera built into its turret. Do you always go the extra mile like that with your mods, and where did you learn to do all that stuff?

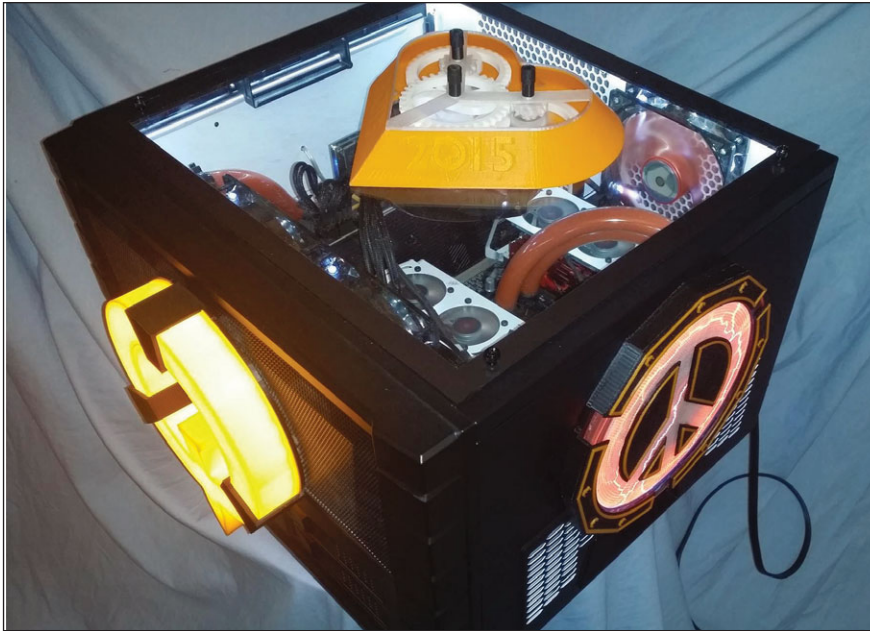
AO: One of my personal rules of modding is functionality. I want it to look cool, but I also want it to have a purpose. I think that flair is required. As for where I learned to do those things, I have always liked knowing how things work. When I was young I would take my toys apart to see how they worked . . . sometimes they even still worked when I put them back together. In the end, all of it is trial and error. Luckily that's one of the things I enjoy.

Q: How long have you been modding now, and how many mods have you completed in that time?

AO: I have been building computers and gaming computers for over 20 years. I have built countless systems for friends and family members that have a little flair added to them. I honestly couldn't give you a number.



Here's a year-by-year retrospective of Owen's QuakeCon builds from 2006 to 2014, with only one repeat: The Behemoth.



Peace, Love and Rockets, Owen's QuakeCon-winning mod from 2015 (Bethesda/id category).

Q : Why did you start modding, and what was your first project?

AO : I had converted part of my parents' house into a LAN center when I was in my teens. My dad had brought home a custom computer desk that he had gotten from work in 1996. I wanted to use the two computers I had on it. I had to custom-design a case that would allow both computers to fit and not be in the way on the desk. I have been hooked ever since.

Q : Of all the mods you built, which is your favorite, and why?

AO : For QuakeCon 2009 I made a computer I called "The Behemoth." It was an old server case my brother-in-law had found in a barn. It was set up for an AT motherboard and a bunch of 5.25-inch hard drives. I was able to gut the computer and fit a phase-change cooler inside the case. I gave the case an automotive paint job and used a plasma cutter to add a window to the side. I then added a watercooling system to it for the video cards. Don't get me wrong, I am proud of the mods I have made in the more recent years, but "The Behemoth" is my favorite this far.

Q : What do you think is the single most important tool in a modder's toolkit, and why?

AO : A drill. I can't think of a single mod I didn't need to drill out rivets or add a hole to a computer that wasn't there. This was the toughest question you asked. So many tools used for every mod I have ever done!

Q : What's your least favorite part of every mod project, and why?

AO : The finishing touches. I always feel like there is more to do and I have to cut myself off and just say it's done. Most of the time it's while the paint is drying and I'm in the hotel about to take the computer to the BYOC at QuakeCon.

Q : It's time for Five Quick Questions!

1) Dremel or air brush?

Dremel!

2) AMD or NVIDIA?

NVIDIA!

3) Egg McMuffin or breakfast burrito?

Egg McMuffin.

4) Cowboys or Texans?

Texans.

5) Peace or rockets?

Love! ■



Bean-with-Bacon Megarocket, a scratch build Owen completed with Rob "Whiskers" Wilson.

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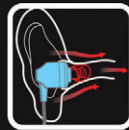
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Classy Chassis

For enthusiasts, a case is not just a container for our PC parts.

A case's interior design can make or break your ability to run high-performance parts and install custom cooling loops. Form factor, airflow, radiator support, and GPU compatibility are just some of things to consider. The chassis is also most power users' primary media for artistic expression. You want your PC to be a showcase, and the perfect case is one that's aesthetically pleasing, matches your build's color scheme, and provides a bit of a "wow" factor.

Don't Temper Your Expectations

Tempered glass side-panel windows are currently the hottest trend in cases. Acrylic windows are still common, but case manufacturers are increasingly moving toward glass panels that provide exceptional visibility and are less likely to scratch than their acrylic counterparts. Tempered glass window panels aren't exactly new, but in the past, such cases often came with prohibitively high price tags. A variety of recently released tempered glass cases are available for less than \$200.

Light It Up

With all of the LED innovation happening to the parts inside your case, it was only a matter of time before big LEDs made their way to case exteriors. There are a lot of interesting takes on LED case lighting. Some of the models in our buyer's guide feature LED light strips that serve primarily as accent illumination, while others build LEDs into the base of the case for ground effects. RGB LEDs, of course, are the ultimate in customization. Some models can even sync up with colors and effects running on the other components in your system.

In this month's buyer's guide, we examine the distinguishing features for more than a dozen cases from leading manufacturers. There are a variety of small form factor units, as well mid-towers and huge chassis that support most any build you can imagine. You'll find a full list of specifications in the chart at the end of the guide.

GIGABYTE XC700W

\$249.99

www.gigabyte.us

Why You'll Dig It: The XC700W's RGB LEDs give you 16.8 million colors to choose from, making it easy to match the color scheme of your build. Best of all, the XC700W's lighting can sync with the LEDs in GIGABYTE's Xtreme Gaming products, as well as GIGABYTE/AORUS motherboards with RGB Fusion. The premium chassis also boasts a full tempered and tinted glass side panel window, a sleek aluminum shell along the front and right-side panels, and a rugged stand with anti-vibration rubber feet. GIGABYTE designs the XC700W to support custom cooling liquid-cooling loops. The top panel supports up to a 360mm radiator, and you can remove the 3.5/2.5-inch drive cage to install a pump and reservoir. To enhance your cable management, the XC700W offers plenty of space behind the motherboard tray, as well as routing holes, to stow excess cabling.

Who Should Apply: Builders who want to take advantage of the XC700W's excellent RGB illumination and support for custom liquid-cooling.

Dimensions: 23.4 x 9.5 x 21.5 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 3 x 3.5/2.5-inch internal, 3 2.5-inch internal



Fractal Design Define C Window Edition

\$84.99 (\$79.99 w/o window)

www.fractal-design.com

Why You'll Dig It: For years, Fractal Design has been perfecting the balance between component flexibility and compact design. The Define C is the company's latest compact ATX case. Notably, the Define C introduces a power supply shroud that features an inset panel you can remove, if you want to install a 360mm radiator into the case's front panel. Fractal Design's ModUVent technology in the top panel dampens sound, while the company's Dynamic X2 GP-12 fans keep noise to a minimum. If you want to install a 240mm radiator into the top panel, you can remove the ModUVent and replace it with a magnetic steel mesh vent. The smooth, clean front panel features baffled air intakes to bring in cool air, while still offering Fractal Design's iconic look. Best of all, the window edition costs only \$84.99.

Who Should Apply: Enthusiasts who want a case that wastes no space, while still supporting high performance components.

Dimensions: 17.8 x 8.13 x 15.8 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 2 x 2.5-/3.5-inch internal, 3 x 2.5-inch internal



Aerocool DS 230

\$119.99 (\$19.99 for optional full-size acrylic side panel)
www.aerocool.us

Why You'll Dig It: Aerocool accents the DS 230 with LED lighting that runs across the top and bottom of the front panel, as well as LEDs just above the pedestal base for some ground effect lighting. You can pick among seven LED colors (red, green, blue, orange, purple, cyan, or white) and configure the lights to remain a static color, pulse, or change color based on the system's PWM fan speed. As a member of Aerocool's Dead Silence lineup, the DS 230 includes a number of features to keep PC noise to a minimum. Both side panels are coated with a layer of sound-dampening material, and the front panel's ventilation features only side-facing and downward facing openings, so sound from the front panel is directed away from you. The DS 230 is also available with a full-size acrylic side panel that costs you only \$19.99.

Who Should Apply: Enthusiasts who want quiet operation and the ability to match case illumination to a build's internal color scheme.

Dimensions: 18.7 x 9 x 18.8 inches
Motherboard Support: Mini-ITX, mATX, ATX
Drive Bays: 2 x 2.5-/3.5-inch internal, 3 x 2.5-inch internal



be quiet! Dark Base Pro 900

\$249
www.bequiet.com

Why You'll Dig It: Earlier this year, the Dark Base Pro 900 received our prestigious *CPU Cutting Edge* award for be quiet!'s exceptional modular case innovations. The Dark Base 900 Pro's motherboard tray is removable, so you can install your motherboard and various other components outside the case if you like, and you can also flip the motherboard tray, as well as move it to one of three heights inside the case. Furthermore, each of the seven internal 3.5-inch drive bays can alternatively house two 2.5-inch drives, and the rack that houses all these bays isn't just removable—you can rotate it so that the trays slide out to the right instead of the left. The internal PSU mounting bracket can reside in up to six positions inside the case. The Dark Base Pro 900 exudes a premium look and feel, in part due to the tempered glass panel—which can also be moved from the left to the right side.

Who Should Apply: Custom loop fanatics who need a case they can customize to work with non-standard, intriguing design choices.

Dimensions: 23 x 9.6 x 22.7 inches
Motherboard Support: Mini-ITX, mATX, ATX, XL-ATX, EATX
Drive Bays: 2 x 5.25-inch external, 7 x 3.5-inch internal, 15 x 2.5-inch internal



ENERMAX STEELWING

\$149.99

www.enermaxusa.com

Why You'll Dig It: Why should big cases get all the tempered glass side panel love? The STEELWING in a small form factor case with a full window to let you show off the impressive, miniature parts of your mATX or Mini-ITX system. ENERMAX also knows that small form factor rigs need quality airflow, so they've designed the case with a semi-open design that optimizes incoming airflow. The STEELWING also features an aluminum material that, according to ENERMAX, provides three times the heat dissipation of a steel PC case. ENERMAX offers the STEELWING with a green or red aluminum exterior and includes a matching LED in the front panel. You can fit a single GPU up to 11.4-inches long, and liquid-cooling support is available via a front-panel HDD bracket that supports either a 3.5-inch HDD or a 120mm radiator.

Who Should Apply: Power users who want to design an attractive, high-performance PC—in miniature.

Dimensions: 11.81 x 6.93 x 15.2

Motherboard Support: Mini-ITX, mATX

Drive Bays: 1 x 3.5-inch internal, 1 2.5-inch internal



Deepcool Genome II

\$229.99

www.deepcool.com

Why You'll Dig It: The Genome was one of our favorite cases of 2016, thanks to its integrated closed-loop CPU cooler, 360mm radiator, and double-helix shaped reservoir. The Genome II features a few notable improvements, including a riser card to vertically mount your GPU (the original featured a riser slot, but didn't come with the riser card). Deepcool also added a removable HDD cage to the front panel, so you can now take the drive cage out if you want to install an additional radiator or fans to the front panel. The Genome's second iteration also features an LED strip behind the double helix reservoir to illuminate coolant on the move. The Genome II is offered in three models. There's one with red coolant and black exterior, one with green coolant and black exterior, and one with blue coolant and a white exterior.

Who Should Apply: Power users who want the look and performance of a high-end cooling loop without having to preplan or install it inside the case.

Dimensions: 19.9 x 8.3 x 20 inches

Motherboard Support: Mini-ITX, mATX, ATX, EATX

Drive Bays: 2 x 3.5-inch internal, 2 x 2.5-inch internal



Aerocool P7-C1

\$119.99 (\$19.99 for optional full tempered glass side panel window)
www.aerocool.us

Why You'll Dig It: Available in white or black, the P7-C1 has a unique look with a recessed mesh front panel featuring an LED accent ring that outlines the mesh inset. The case's large side panel window (or optional full tempered glass side panel window) further adds to its high-end, stylish appearance. We also like that the LED accent ring can be configured to one of eight color choices. Aerocool designs the P7-C1 with excellent support for airflow and liquid-cooling components. The case comes with a single 120mm fan mounted on the inside of the rear panel and provides mounting spots for another three 120mm fans or two 140mm fans behind the front panel, as well as mounts for two more 120mm fans underneath the top panel. In terms of radiators, the case will hold up to 240mm on top and up to 360mm in front. An optional, full tempered glass window side panel is also available for \$19.99.

Who Should Apply: Power users pushing their PC's components to the limit who need a mid-tower case that keeps everything cool.

Dimensions: 18.7 x 8.2 x 16 inches
Motherboard Support: Mini-ITX, mATX, ATX
Drive Bays: 2 x 3.5-inch internal, 4 x 2.5-inch internal



Fractal Design Node 202 And Integra SFX 450W PSU

\$139.99
www.fractal-design.com

Why You'll Dig It: With a size and look to match videogame consoles and entertainment center devices, the Node 202 is perfectly designed for PC gamers who want to play on their home's big screen. This model also comes with Fractal Design's Integra SFX 450W, a small form factor PSU with customized connectors and cables fitted for use inside the Node 202. The custom wiring makes it easy to work inside the case and install parts, such as your build's mini-ITX motherboard. You can build a fairly powerful gaming PC with the Node 202, as the case supports many full-sized GPUs (up to 12.2 inches long). To alleviate heat concerns, Fractal Design separates the GPU in its own chamber, and a riser card is used to attach the GPU to the motherboard's PCIe slot. The Node 202 can be set up vertically or horizontally.

Who Should Apply: HTPC and big-screen gamers looking for a case that will fit in beautifully with their home theater gear.

Dimensions: 3.46 x 14.84 x 13.1 inches
Motherboard Support: Mini-ITX
Drive Bays: 2 x 2.5-inch internal



Zalman Z1 NEO

\$49.99

www.zalman.com

Why You'll Dig It: Overspend your budget on PC parts and need to make up the difference with your case? Zalman has you covered with the Z1 NEO. It looks the part of a more expensive case with a transparent acrylic side panel window, two 120mm blue LED fans in the front panel, and black internals to perfectly match the case exterior. Zalman preinstalls three 120mm fans with the two blue LED fans pulling in cool air, while the rear 120mm fan exhausts hot air from the case. To cool the PSU, Zalman provides a vent in the bottom of the case, and this vent is fitted with a dust filter to prevent dust from accumulating in your PSU. Most high-end graphics cards will fit inside the Z1 NEO, as it supports GPUs up to 14.7 inches long.

Who Should Apply: Budget builders who require a case with excellent cooling and a side panel window.

Dimensions: 17.5 x 8 x 17.6 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 1 x 5.25-inch external, 4 x 3.5-/2.5-inch internal,
1 x 2.5-inch internal



Rosewill GUNGNIR X

\$64.99 (using CPUMAG17 promocode; normally \$74.99)

www.rosewill.com

Why You'll Dig It: The GUNGNIR X, like its GUNGNIR predecessor, features a top and bottom chamber to separate case airflow into two streams. You install the PSU and storage devices in the bottom chamber, which isolates heat and prevents the CPU and GPU from being affected by heat from subsystem hardware. The GUNGNIR X is longer than the original, and Rosewill uses the space to improve liquid-cooling and GPU support. The top panel now supports up to a 360mm radiator (GUNGNIR maxed out at 280mm), and you can install GPUs up to 16.5 inches long (GUNGNIR maxed out at 15.75 inches). A large window side panel provides a good look at internal components, and you can hide many of the cables in the bottom chamber. During the month of February, apply promocode CPUMAG17 to purchase the case for \$64.99.

Who Should Apply: Enthusiasts who want an affordable case that helps them to minimize cable visibility, as well as optimize cooling performance.

Dimensions: 19.57 x 8.27 x 18.90 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 2 x 5.25-inch external, 2 x 3.5-inch/2.5-inch internal, 3 x 2.5-inch internal



ENERMAX Ostrog ADV

\$119.99

www.enermaxusa.com

Why You'll Dig It: ENERMAX applies its MaxBrite LED technology as an accent trim on the Ostrog ADV to light up the case's front and top panels. The warm LED glow (available in red, blue, or green) is complemented by Vegas LED fans behind the front panel that match the color of its MaxBrite strips, as well as matching paint on its motherboard tray and matching mesh expansion slot covers. The MaxBrite strips also sync with the Vegas fans to run in six modes, including On, Dimmed, Flash, Sparkle, Vegas, and Off, which you can control using a button on the case's top-facing I/O panel. Other high-end amenities include an oversized acrylic side-panel window, quick release panels in the front and top, and support for GPUs up to 16 inches long.

Who Should Apply: Builders in need of a case to enhance and expand a system's color scheme—both inside and out.

Dimensions: 20.3 x 8.5 x 19.4 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 3 x 5.25-inch external, 6 x 3.5-inch/2.5-inch internal



CaseLabs Bullet BH4

\$189.95

caselabs-store.com

Why You'll Dig It: The Bullet BH4 is a great looking small form factor case. (We got a chance to test out the Lime Green model, which looked fantastic.) The case comes with premium-quality paint, available in Black, White, or Gunmetal, and in Tangerine, Lime or Berry for an extra \$10. The mATX chassis is a mere 10 inches high, 11 inches wide, and 13 inches deep—a footprint that should fit most anywhere. CaseLabs also offers a Mini-ITX little sibling (the BH2) and a big ATX/EATX brother (the BH7). The Bullet BH4 is divided into two compartments. Your drives install on the case's bottom compartment along with your power supply; your motherboard will lay flat on the motherboard tray that's just above. A dual 120mm radiator fan mount is included to add a fan or an AIO liquid cooler's radiator. Optionally, you can also add a custom carrying handle and an LED light bar.

Who Should Apply: Small form factor enthusiasts in the market for a smartly designed, smart-looking mATX case.

Dimensions: 9.5 x 11 x 13 inches

Motherboard Support: mATX

Drive Bays: 2 x 3.5-inch internal, 3 x 2.5-inch internal



Rosewill CULLINAN

\$139.99 (promotional price in February; normally \$149.99)
www.rosewill.com

Why You'll Dig It: Named after the largest gem-quality diamond ever found, the CULLINAN features three tinted, tempered glass panels to provide an unparalleled view of system internals. The case also comes with four blue 120mm LED fans, three of which are preinstalled into the front panel. The bright blue illumination shines through the tinted glass and adds some pizzazz right out of the box. With three sides of transparent glass, Rosewill smartly includes a large PSU shroud where you can tuck away and hide excess cabling. The CULLINAN also includes a fan controller hub that supports six PWM fans to further help reduce fan cable visibility. Both the top and front panels support up to a 360mm radiator, and liquid cooling will definitely look great inside this case. When you purchase the CULLINAN during February, you'll also receive Rosewill's RGH-3300 Gaming Pro headset (\$49.99 MSRP) for free.

Who Should Apply: Power users who want a clear view of their system's exquisite hardware and LEDs.

Dimensions: 19.57 x 8.54 x 18.78 inches
Motherboard Support: mATX, ATX, XL-ATX, EATX
Drive Bays: 3 2.5-/3.5-inch internal



Antec Cube - Designed By Razer

\$269
www.antec.com

Why You'll Dig It: It's a striking Mini-ITX case with Razer-themed touches, including the iconic triple-snake logo on the front panel and green LED light bars that illuminate the case's underbody. Other external design highlights include the Cube's side panels, which wrap around to the top and bottom of the case, matching the front panel's unique shape. Both panels have tinted acrylic windows that provide a glimpse of the case's contents, and both pop on and off easily without the need to mess around with thumbscrews. There's another tinted acrylic window set into the Cube's top panel. Airflow comes through the vertical ventilation slats, and the case supports up to a 240mm radiator in the front panel and up to a 140mm in the rear panel. A basement compartment is provided to conceal cables.

Who Should Apply: Builders who want a stylish small form factor case that supports liquid-cooling.

Dimensions: 14.37 x 9.84 x 18.11
Motherboard Support: Mini-ITX
Drive Bays: 1 x 3.5-inch/2 x 2.5-inch internal, 2 x 2.5-inch internal



Thermaltake The Tower 900

\$249.99

www.thermaltakeusa.com

Why You'll Dig It: The Tower 900 is a huge chassis (nearly 30 inches tall) with big tempered glass windows on the front and sides. The design makes it a perfect case for modders and expert builders who need space for massive custom cooling loops and big, bold reservoirs. Thermaltake also isolates the radiators in the back of the case, allowing for maximum cooling performance. You can install up to dual 560mm radiators—one on each side of the case—ideal for extreme mods with impressive dual loop liquid cooling systems. The Tower 900 orients the motherboard so that your GPUs sit vertically to eliminate “GPU sag” that can occur when big, heavy GPUs are mounted horizontally.

Who Should Apply: Modders who want a case that can support anything they dream up.

Dimensions: 29.6 x 16.7 x 19

Motherboard Support: Mini-ITX, mATX, ATX, EATX

Drive Bays: 1 5.25 external,

6 x 3.5-/2.5-inch internal, 2 x 2.5-inch internal



Zalman Z9 NEO

\$79.99

www.zalman.com

Why You'll Dig It: Don't be misled by the Z9 NEO's \$79.99 price tag, as this mid-tower is brimming with amenities for enthusiasts. The case, available in white and black, has a ventilated PSU shroud to keep cabling neat and provide a separate cooling zone for your power supply and any drives you have installed in the two-bay cage toward the front of the case. Additional storage support is available via two vertical 2.5-inch mounts on the back of the motherboard tray, so all of your storage devices will be located outside of the main interior space. The Z9 NEO is optimized for airflow right out of the box, thanks to five pre-installed 120mm fans. Zalman installs a soundproof pad to the inner part of the front panel door, which helps to keep fan noise to a minimum. You can install a 240mm radiator in both the front and top panel.

Who Should Apply: Builders looking for a case with a flexible interior design and great look for less than a Benjamin.

Dimensions: 19.29 x 8.07 x 18.98

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 2 x 5.25-inch external, 2 x 3.5-/2.5-inch internal,
2 x 2.5-inch internal



be quiet! Pure Base 600

\$89.90

www.bequiet.com

Why You'll Dig It: The Pure Base 600 is one of the most budget-friendly be quiet! cases available, yet it comes with many of the company's modular designs for optimal build flexibility. For example, the adjustable top panel can be raised up—using the ridged tab inserts—to vent hot air and support a 120, 240, or 360mm radiator. Prefer a more silent build and don't need the extra breathability? Just lower the top panel. be quiet! also includes a removable optical disc drive cage and a repositionable 2.5/3.5-inch drive cage with three bays. There are also two removable 2.5-inch mounts behind the motherboard tray. For quiet operation, the Pure Base 600 comes with the company's excellent case fans. There's a 140mm Pure Wings 2 intake fan up front and a 120mm model in the rear for exhaust. Both fans are connected to the three-step fan control switch.

Who Should Apply: Power users on a tight budget who need a case flexible enough to handle whatever components the system requires.

Dimensions: 18.5 x 8.7 x 19.4 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 2 x 5.25-inch external, 3 3.5-inch/2 2.5-inch internal, 2 x 2.5-inch internal



GIGABYTE XC300W

\$99.99

www.gigabyte.us

Why You'll Dig It: For only \$99.99, the XC300W comes with a remarkable number of first-class case amenities. To start, the "X" and GIGABYTE Xtreme Gaming logo on the front feature 16.8 million color RGB lighting. GIGABYTE also provides a transparent full side panel window for visibility to each and every part of your build. If you have an attractive graphics card to show off, you'll like that the XC300W lets you vertically mount the card. Conventional horizontal GPU mounting is supported, as well. The case's PSU shroud lets you hide cabling and prevent PSU heat from affecting other system components. The PSU shroud also conceals two 3.5/2.5-inch drive bays, and there are two 2.5-inch mounts behind the motherboard tray. The XC300W supports graphics cards up to 16.1 inches long.

Who Should Apply: Gamers and enthusiasts who want to show off system components without spending more than \$100 on a case.

Dimensions: 17.3 x 8.3 x 18.5 inches

Motherboard Support: Mini-ITX, mATX, ATX

Drive Bays: 2 x 3.5/2.5-inch internal, 2 2.5-inch internal



Case	MSRP	Motherboard Support	Internal Drive Bays	External Drive Bays	Max GPU Length (inches)	Fans (standard/optional)	Dimensions (inches; HxWxD)
Antec Cube - Designed By Razer	\$269	Mini-ITX	1 x 3.5-inch/ 2 x 2.5-inch, 2 x 2.5-inch	none	13.7	1/2	14.37 x 9.84 x 18.11
GIGABYTE XC700W	\$249.99	Mini-ITX, mATX, ATX	3 x 3.5/2.5-inch, 3 x 2.5-inch	none	16.9	1/3	23.4 x 9.5 x 21.5
Thermaltake The Tower 900	\$249.99	Mini-ITX, mATX, ATX, EATX	6 x 3.5-/2.5-inch, 2 x 2.5-inch	1 x 5.25-inch	15.7	0/13	29.6 x 16.7 x 19
be quiet! Dark Base Pro 900	\$249.00	Mini-ITX, mATX, ATX, EATX, XL-ATX	7 x 3.5-inch, 15 x 2.5-inch	2 x 5.25-inch	18.5	3/7	23 x 9.6 x 22.7
Deepcool Genome II	\$229.99	Mini-ITX, mATX, ATX, EATX	2 x 3.5-inch, 2 x 2.5-inch	none	12.9	4/2	19.9 x 8.3 x 20
CaseLabs Bullet BH4	\$189.95	mATX	2 x 3.5-inch, 3 x 2.5-inch	none	11	0/4	9.5 x 11 x 13
ENERMAX STEELWING	\$149.99	Mini-ITX, mATX	1 x 3.5-inch, 1 x 2.5-inch	none	11.4	1/0	11.81 x 6.93 x 15.2
Rosewill CULLINAN	\$139.99	mATX, ATX, EATX, XL-ATX	2 x 2.5-/3.5-inch, 3 x 2.5-inch	none	16.5	4/3	19.57 x 8.54 x 18.78
Fractal Design Node 202 + Integra SFX 450W PSU	\$139.99	Mini-ITX	2 x 2.5-inch	none	12.2	0/2	3.46 x 14.84 x 13.1
Aerocool P7-C1	\$119.99	Mini-ITX, mATX, ATX	2 x 3.5-inch, 4 x 2.5-inch	none	14.7	1/5	18.7 x 8.2 x 16
ENERMAX Ostrog ADV	\$119.99	Mini-ITX, mATX, ATX	6 x 3.5-inch/2.5- inch	3 x 5.25-inch	16	3/3	20.3 x 8.5 x 19.4
Aerocool DS 230	\$119.25	Mini-ITX, mATX, ATX	2 x 2.5-/3.5-inch, 3 x 2.5-inch	none	15.25	1/5	18.7 x 9 x 18.8
GIGABYTE XC300W	\$99.99	Mini-ITX, mATX, ATX	2 x 3.5/2.5-inch, 2 x 2.5-inch	none	16.1	2/4	17.3 x 8.3 x 18.5
be quiet! Pure Base 600	\$89.90	Mini-ITX, mATX, ATX	3 x 3.5-/2.5-inch, 2 x 2.5-inch	2 x 5.25-inch	16.7	2/4	18.5 x 8.7 x 19.4
Fractal Design Define C Window Edition	\$84.99	Mini-ITX, mATX, ATX	2 x 2.5-/3.5-inch, 3 x 2.5-inch	none	12.4	2/4	17.8 x 8.13 x 15.8
Zalman Z9 NEO	\$79.99	Mini-ITX, mATX, ATX	2 x 3.5-/2.5-inch, 2 x 2.5-inch	2 x 5.25-inch	16.5	5/0	19.29 x 8.07 x 18.98
Rosewill GUNGNIR X	\$64.99	Mini-ITX, mATX, ATX	2 x 3.5/2.5-inch, 3 x 2.5-inch	2 x 5.25-inch	16.5	3/3	19.57 x 8.27 x 18.90
Zalman Z1 NEO	\$49.99	Mini-ITX, mATX, ATX	4 x 3.5-/2.5-inch, 1 x 2.5-inch	1 x 5.25-inch	14.7	3/0	17.5 x 8 x 17.6

DirectX 12: Hype Or Hypnotic?

Back in June 2015, we took an in-depth look at Microsoft's DirectX 12, the latest gaming-focused API that's exclusive to Windows 10. Because that OS went on sale a month after that article's publication, our coverage was necessarily limited to an analysis of the "on-paper" benefits of DX12. To truly experience DX12's streamlined graphics pipeline and better multithreaded scaling, games that leverage the new API need to become available, and as we learned from DX10's disastrous face-plant, (which may owe its failure more to its Windows Vista exclusivity than to any one feature or flaw), those games may never materialize.

Fast forward to today: We're happy to report that there are a decent number of DX12-exclusive games and even more that had optional DX12 running modes either at launch or patched in shortly thereafter. Perhaps most promising of all, the DX12 games that are currently available, including Forza Horizon 3, Gears Of War 4, Star Wars Battlefront, Rise Of The Tomb Raider, HITMAN, Deus Ex: Mankind Divided, and Battlefield 1 rank as some of the best games of last year. The API also currently enjoys hearty support from most modern game engines and numerous publishers. Although we're still in DX12's relative infancy, we're confident that it has a bright future.

A DirectX 12 Snapshot

DirectX 12's utility to PC gamers is a bit of a moving target at the moment. Evolving graphics hardware, OS tweaks, driver improvements, and developer support all tend to have a huge impact on the performance of a given title at a given point in its life span. Unfortunately, anytime we set out to weigh the advantages and drawbacks of making a particular upgrade, all we have to go on



Will DirectX 12 herald the renaissance PC gamers have been waiting for?

is the data available to us at the time. As such, it is our goal with this article to document the impact of DX12, if any, to help you make a more informed decision when it comes time to upgrade.

Promises, Promises

Before we dig into the numbers, let's recap some of the reasons DX12 seems to be getting off to such a healthy start. From a consumer standpoint, the new API is compelling because it was built to be significantly more power-efficient, resulting in better performance for gamers running even mainstream or entry-level components. Features such as descriptor tables and concise pipeline state objects, for instance, enable Win10 to better pair up the graphics hardware with the appropriate DirectX abstraction layer. This lower-level abstraction is a key component of DX12, but it's

also something that older DX11-based graphics cards from AMD and NVIDIA supported at Win10's launch.

DX11 is good at many things, but CPU utilization under this API was always seen as unnecessarily high. One way DX12 solves this problem is through the use of draw call bundles, officially introduced in Xbox One as a part of its modified DirectX 11.x API. These allow the rendering hardware to bundle and cache a series of operations likely to be reused. When that series is called for again, it executes with little to no overhead. Developers can also employ descriptor heaps and tables to store frequently-used resources to further spread the workload across the CPU and GPU more efficiently. Command lists, like draw call bundles, are yet another feature designed to decrease the number of repetitive tasks that the CPU performs. In short, DX12 is born to multithread.

Other signature DX12 capabilities include volume tiled resources and conservative rasterization, which are both prerequisites for a realistic lighting technique called Voxel Global Illumination. This feature is also planned to be a part of DX11.3, which seeks to backport some of DX12's features for Win7 and Win8/8.1 users. Conservative rasterization differs from standard rasterization in that it is capable of producing more accurate results with regard to collision detection, occlusion culling, and shadow acceleration. Other features that require Win10 and DX12-compliant hardware include Shader Model 5.1 support, shader-specified stencil reference values, typed UAV load, standard swizzles, default texture mapping, swap chains, swizzled resources, compressed resources, and a series of new blend modes. In DX12, raster ordered views enable real-time order-independent transparency without crippling the rendering hardware. This feature could be used to render more life-like blended textures and complex transparent objects such as smoke, fire, and water. New concise pipeline state objects simplify how the state-changing process occurs and unify the pipelines to slash overhead and let the graphics hardware perform more calls per frame.



The Xbox One even gets a taste of DirectX 12's secret sauce.

R.I.P. SLI & CrossFire

DX12's new Explicit Multi-Adapter feature is another reason PC gamers can get excited. It lets games detect scenarios where more than one graphics adapter is present, from any vendor, and then enables the system to divvy up the workload in a variety of ways. Since DirectX 9, successfully running multiple graphics adapters was heavily reliant on vendors AMD and NVIDIA and their

respective CrossFire and SLI technologies, and the most common technique for splitting game workloads between two or more GPUs is AFR, or alternate frame rendering. This essentially gives frame No. 1 rendering duties to GPU A, and frame No. 2 rendering duties to GPU B, and so on and so forth. DX9 through DX11's APIs just saw two sequential frames coming from a single chunk of graphics hardware.

AFR is essentially a workaround for an API that lacks specific support for more than one graphics adapter. It typically wouldn't work unless the graphics adapters were identical models or at least very close to one another in performance, and when it worked, input lag was a common side effect. Furthermore, when you run two graphics cards with 4GB of GDDR5 each, for example, DX11 and prior APIs still only recognize 4GB of total memory, instead of the combined 8GB. All frames rendered ultimately get copied to both frame

SPLIT-FRAME RENDERING

SUPREMELY RESPONSIVE MULTI-GPU GAMING

DIRECTX® 11

- Multi-GPU uses alternate-frame rendering (AFR)
- GPU A renders even frames, GPU B renders odd
- As a frame is shown to the user, the other GPU is already placing a new frame into a queue
- Preparing multiple frames in a queue raises FPS, but reduces game responsiveness as the frames wait in line

DIRECTX® 12

- New mode available to devs: split-frame rendering (SFR)
- Each frame of a game is split into a tile
- Each GPU in the system renders one tile
- Frames no longer need to be queued; time between frame completion and user viewing reduced by 2-3x
- Using the GPUs in parallel to work on one frame allows multiple GPUs to behave like one much more powerful GPU

28 | DIRECTX® 12 & AMD RADEON™ GRAPHICS | MAY, 2015 | APPROVED FOR ALL AUDIENCES

DID YOU KNOW?
AMD pioneered SFR for the modern era with Mantle. It was used in Sid Meier's Civilization™: Beyond Earth™.

DirectX 12's Explicit Multi-Adapter feature could render CrossFire and SLI unnecessary.

buffers, which is another major drawback of CrossFire and SLI. As anyone who has used SLI or CrossFire knows all too well, it doesn't always work, and sometimes it even hinders performance compared to running the game with a single graphics card.

Explicit Multi-Adapter in DX12 changes all that and brings along a handful of new techniques for dividing up the workload between all GPUs. Split-frame rendering essentially divides each frame into multiple tiles and distributes the tile-rendering tasks to the different adapters. Asymmetric multi-GPU is another technique that lets a game divide rendering tasks unequally, between a discrete graphics card and an on-CPU graphics adapter. For instance, the heavy lifting of the game rendering would likely fall to the discrete GPU, while something like lighting, physics, or post-processing would be handled by the integrated adapter. DX12 also lets the game workload see the two or more distinct pools of graphics memory as a single combined pool, so two cards with 4GB each let the DX12 API access all 8GB.

Asynchronous Compute

There's a lot of information on the internet about Asynchronous Compute, but depending on your sources, you're likely to come away with three different impressions of how it works based on the terminology used by AMD, NVIDIA, and Microsoft. The important takeaway is that Asynchronous Compute is designed to eliminate GPU workload inefficiencies that crop up primarily when gaming.

When AMD and NVIDIA come up with new GPU architectures, most of the changes that occur from one generation to another are designed to ensure that when the GPU is working, it is working hard, with 100% utilization, to give you the fastest frame rates, at the highest resolution, with as much eye candy as your visual cortex can handle. This is an incredibly tricky thing to do using a GPU that is largely comprised of a hundreds or thousands of general-purpose units, with limited amounts



Our SAPPHIRE RX 480 NITRO+ has four ACEs, with each one supporting up to eight queues.



The GIGABYTE GTX 1060 G1 Gaming 6GD features Pascal's revamped scheduler, which is designed to better adapt to DX12 workloads.

of cache, and a handful of specialized function units that handle post-processing duties. Giving developers a way to get more performance from a given bit of hardware, either in a console or PC, is always a good thing.

According to Microsoft, DX12's take on Asynchronous Compute is referred to most often as Synchronization and Multi-Engine. In essence, this aspect of the API lets game developers employ queues and command lists to execute dozens, hundreds, or even thousands of threads concurrently without having to have those items pause to wait their turn. When synchronizing the thread output

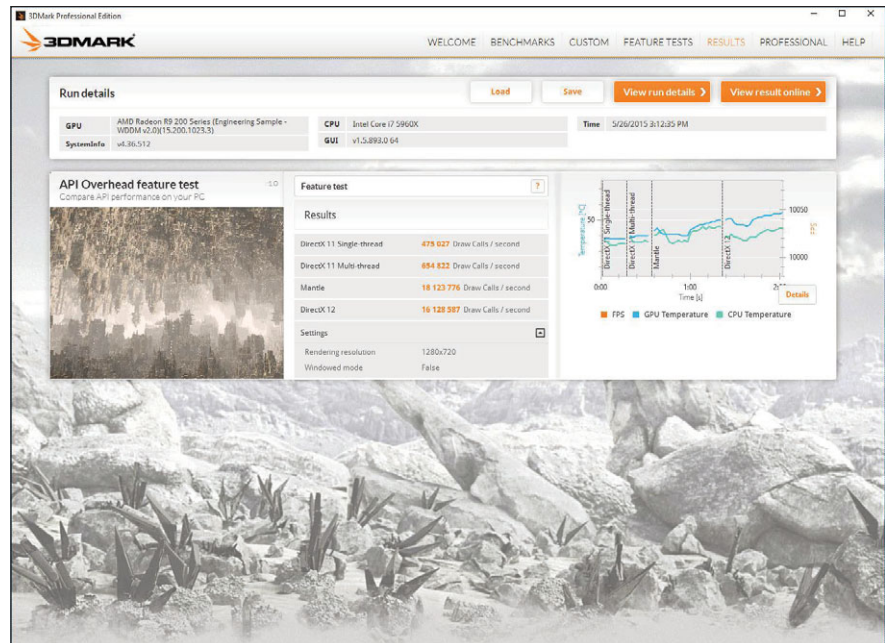
becomes necessary, developers also have more control over when and how that happens. These functions are good at filling in the gaps compared to the more traditional render path of a modern GPU, but it's not a complete overhaul of the process by any means. The performance bump DX12 delivers for a game that uses this technique vs. the same game running under DX11 tops out at about 20%, but we suspect this performance improvement is restricted to the times when the GPU is at its most inefficient. In short, Microsoft's Synchronization and Multi-Engine techniques are all about filling in the gaps to keep GPU utilization maxed out.

When talking about thousands of threads running in parallel, AMD's architecture is the one that, at least on paper, appears to be better able to take advantage of DX12's Multi-Engine approach. The AMD Radeon RX 480 has 2,304 stream processors, almost twice as many general-purpose processors such as the NVIDIA GeForce GTX 1060, which features 1,280 CUDA cores. Traditionally, multithreaded graphics workloads are synchronous, which means that there's just one queue, and everything that passes through is scheduled and synchronized in advance.

The Polaris architecture of AMD's RX 400 Series GPUs (and most previous GCN-based GPUs) feature what AMD calls ACEs, or Asynchronous Compute Engines, which, when running in a DX12 environment, give developers access to command lists that they can submit to three queues: graphics, compute, and copy. This opens up AMD's ACEs to significantly more of the heavy lifting of games, including rendering 3D objects, calculating AI, and performing lighting, shadowing, and camera effects workloads. The SAPPHERE Radeon RX 480 NITRO+ we used for our testing features four ACEs, and each ACE supports up to eight queues.

To further illustrate AMD's favorable position with regard to DX12, it's also important to point out that many consider AMD's Mantle graphics API to have been the kick in the pants Microsoft needed to roll out DX12. Back when AMD was working on Mantle, the firm's goal was to create a 3D rendering and gaming-centric API that lets developers get "closer to the metal," which in developer-speak means unfettered access to the GPU, all of the cores of the CPU, and the system memory. Sound familiar? In 2015, AMD donated Mantle to the Khronos Group, and the organization renamed it Vulkan. 2016's DOOM is an example of a game that runs on either OpenGL or the Vulkan API.

The role consoles play in the success of a gaming API should not be downplayed. AMD's hardware is under the hood of the Xbox One, PS4, as well as the souped-up PS4 Pro and Project Scorpio, which is



The API Overhead test, while interesting, doesn't give us any idea how DirectX 12 games will perform in a real-world scenarios.

giving game developers who work on multiplatform titles plenty of access to AMD's async shader architecture.

You may have heard that NVIDIA hardware can't perform Asynchronous Compute, but that's just not true. The firm's Maxwell and Pascal architectures (GeForce GTX 900/1000 Series) are capable of letting command lists break up tasks to run in multiple queues, but NVIDIA has a different bag of tools for getting the job done. In Pascal, each SM (streaming multiprocessor) features a geometry engine, with rasterizers shared by all SMs in a GPC (graphics processing cluster). The GIGABYTE GeForce GTX 1060 G1 Gaming 6GD we're using in this article features three GPCs and 10 SMs. Not a whole lot of the underlying structure of the GPU's architecture changed between Maxwell and Pascal, but the latter now features a revamped scheduler designed to leverage Microsoft's Synchronization and Multi-Engine strategy to improve SM utilization. Again, filling in the gaps for those times when GPU utilization drops slightly.

In head-to-head scenarios, using largely synthetic tests, it appears as though

NVIDIA's architecture yields the better results under lighter workloads; however, AMD's architecture pulls ahead when those command lists start churning out more and more tasks to fill up those parallel queues. Although AMD got a bit of a head start on NVIDIA, both vendors are tailoring their respective GPU architectures to enable DX12's most promising features. Console and PC game developers are diving in with both feet, and the DX12 games we have access to today are nothing short of stellar.

Putting DX12 To The Test

A year and a half ago, we had no real option for testing DX12 with real-world workloads. As a result, we were forced to rely on one of the few tests available at the time, Futuremark API Overhead feature test, which is designed to hammer the system with draw calls per frame until the frame rate drops below a playable 30fps. On a test system that relied on a decidedly midrange SAPPHERE Radeon R9 285 graphics card with 2GB of GDDR5 memory, our multi-threaded scores jumped from 655,000 draw calls per second to more than 16 million draw

calls per second in DX11 and DX12, respectively. Although that sounds impressive, it's still a synthetic test, and the workloads it generates aren't even remotely similar to the workloads a typical game would put your system through.

But things are different now. To document DX12's real-world impact on games under AMD and NVIDIA architectures, we'll be using one synthetic benchmark and four real-world game benchmarks that let us test in both DX11 and DX12 modes. To reiterate, we're pitting a SAPPHIRE Radeon RX 480 NITRO+ against a GIGABYTE GTX 1060 G1 Gaming 6GD, two midrange cards that can be had for about \$250 as we went to press. We also selected

these two cards because neither card is a clear winner, when priced equally, when subjected to a handful of DX11 and DX12 games. We ran the game benchmarks at both 1,920 x 1,080 and 2,560 x 1,440, which is the sweet spot for these cards in most games.

The 3DMark Time Spy test, the synthetic benchmark, differs significantly from the API Overhead feature in that it is designed to at least mimic realistic gaming workloads in addition to natively supporting a host of DX12's headlining features, including Asynchronous Compute, Explicit Multi-Adapter, and multithreading.

As one of the most recent examples of an AMD Gaming Evolved title to implement DX12, IO Interactive's HITMAN takes

advantage of Asynchronous Compute. We tested this game in DX11 and DX12 with the Level Of Detail slider set to Ultra, SMAA enabled, and texture quality maxed.

Rise Of The Tomb Raider got its DX12 running mode patched-in post release, and it's an NVIDIA TWIMTBP (The Way It's Meant To Be Played) title. The game was running on the Very High graphics preset, with SMAA enabled, and we used the overall score for our results.

The third game we ran was Deus Ex: Mankind Divided, another AMD Gaming Evolved title, at the Very High preset, with 4X MSAA. According to an AMD Community blog post, Deus Ex also uses Asynchronous Compute to yield "more efficient use of your GPU to enable

SAPPHIRE Radeon RX 480 8GB NITRO+		Specs & Scores		
Core clock (Quiet) / (Boost)	1,266MHz / 1,342MHz	Games (1,920 x 1,080)	DirectX 11	DirectX 12
Memory clock	2,000MHz	HITMAN (Ultra Detail, SMAA, High Textures)	74.37fps	85.51fps
Memory / Interface	8GB GDDR5 / 256-bit	Rise Of The Tomb Raider Mt. Peak (SMAA, V. High)	71.86fps	72.81fps
3DMark Fire Strike Extreme Score	5,384	Deus Ex: Mankind Divided (4xMSAA, V. High)	26.4fps	27.7fps
Graphics Test 1	27.45fps	Ashes Of The Singularity Overall (2xMSAA, Crazy)	32.6fps	38.7fps
Graphics Test 2	21.30fps	Games (2,560 x 1,440)	DirectX 11	DirectX 12
3DMark Time Spy Graphics Score	4,279	HITMAN (Ultra Detail, SMAA, High Textures)	57.18fps	62.43fps
Graphics Test 1	26.59fps	Rise Of The Tomb Raider Mt. Peak (SMAA, V. High)	48.24fps	50.3fps
Graphics Test 2	21.7fps	Deus Ex: Mankind Divided (4xMSAA, V. High)	16.1fps	16.9fps
CPU Test	30.2fps	Ashes Of The Singularity Overall (2xMSAA, Crazy)	27.7fps	31.9fps

GIGABYTE GTX 1060 G1 Gaming 6GD		Specs & Scores		
Core / Boost clock (OC Mode)	1,621MHz / 1,848MHz	Games (1,920 x 1,080)	DirectX 11	DirectX 12
Memory clock	2,002MHz	HITMAN (Ultra Detail, SMAA, High Textures)	71.2fps	75.77fps
Memory / Interface	6GB GDDR5 / 256-bit	Rise Of The Tomb Raider Mt. Peak (SMAA, V. High)	81.51fps	75.03fps
3DMark Fire Strike Extreme Score	6,109	Deus Ex: Mankind Divided (4xMSAA, V. High)	26.7fps	25.4fps
Graphics Test 1	32.2fps	Ashes Of The Singularity Overall (2xMSAA, Crazy)	42.1fps	40.9fps
Graphics Test 2	23.73fps	Games (2,560 x 1,440)	DirectX 11	DirectX 12
3DMark Time Spy Graphics Score	4,108	HITMAN (Ultra Detail, SMAA, High Textures)	53.12fps	55.25fps
Graphics Test 1	26.71fps	Rise Of The Tomb Raider Mt. Peak (SMAA, V. High)	52.43fps	49.01fps
Graphics Test 2	23.61fps	Deus Ex: Mankind Divided (4xMSAA, V. High)	16.3fps	16.4fps
CPU Test	31.37fps	Ashes Of The Singularity Overall (2xMSAA, Crazy)	34.6fps	33.8fps



DirectX 12 isn't a win for everybody in every scenario, but we're excited to see where games go from here.

a more immersive gaming experience due to increased graphics clarity, high frame rates, and enhanced AI." That's a good thing, because of all the games we tested, this one is by far the most demanding; both cards struggled to run it at 1080p with the settings maxed out.

The last game we used is one of the first to take advantage of DX12's extra

muscle, Ashes Of The Singularity. This game is another one of AMD's Gaming Evolved titles. The scores we reported are the overall, with 2X MSAA enabled and the Crazy quality profile selected.

The Verdict

As you can see in the charts and graphs, DX12 is rarely a non-factor. At

both the 1080p and 1440p resolutions, AMD's GPU showed an advantage in every game when running under DX12. NVIDIA's GPU running games in DX12, on the other hand, showed a decrease in performance compared to DX11 in every game except for HITMAN at both resolutions and Deus Ex Mankind Divided at 1440p, although by just a tenth of a frame per second.

Although AMD's performance advantage was all over the place, from as little as a single frame per second to as many as 10 frames per second, we feel confident recommending AMD hardware owners take advantage of the DX12 mode in games. For NVIDIA hardware owners, DX11 is your best bet, but don't hesitate to try out the DX12 modes of your games on a case-by-case basis to see if there are benefits.

Lucky Number 12

Julien Bouvrais, CTO of Deus Ex: Mankind Divided's Eidos-Montreal, called DX12 "the fastest adopted API in the last decade." Even before Windows 10 launched, Square Enix showed off one of the earliest DX12 demos at the Build Developer Conference, and it reportedly took the team just three weeks to get

its Luminous Engine to run in DX12. In interviews, the team claimed that leveraging the API wasn't very difficult. Although game performance in the coming months and years will likely change as developers learn how best to optimize their engines and games, it's clear to us that gamers have a lot to look forward to thanks to DX12. ■

Inside The World Of Betas

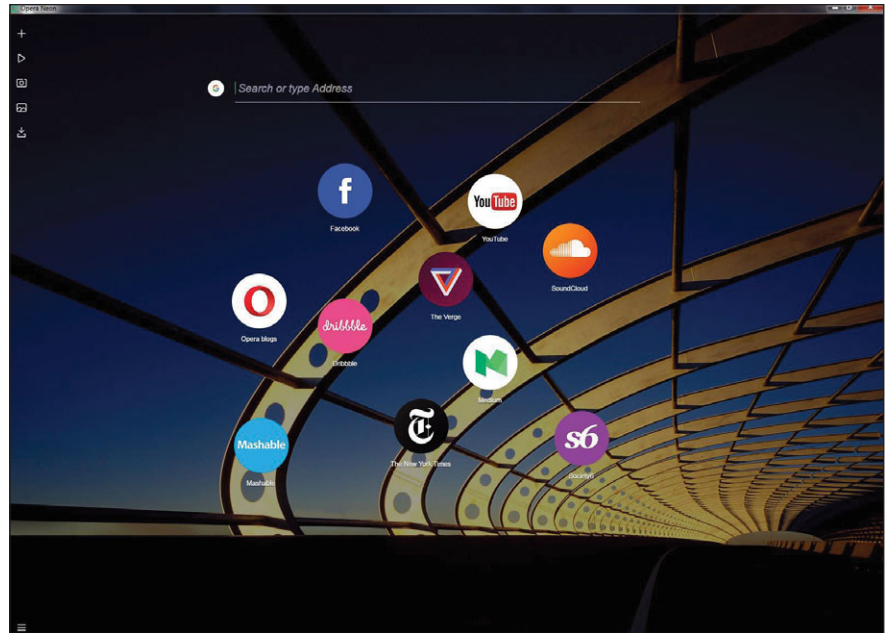
OPERA NEON 1.0.2459.0

What does it take to “disrupt” web browsers these days? As far as market share goes, the Big Three—Chrome, Firefox, and Edge/Internet Explorer—have been firmly entrenched for a while. The remaining horde of less popular browsers usually rely on a novel feature or two to gain an edge as they scuffle over the sliver of pie that’s left over.

Then there’s Opera. Existing in a kind of purgatory between the Big Three and all the other fringe browsers, Opera has always maintained a loyal following, but it’s never been a browser that people have flocked to *en masse*. Now, Opera Software wants to give you a glimpse of what the future of web browsing could look like, introducing Opera Neon, which the developer is calling a “concept browser.”

Opera Neon isn’t quite beta software in the strictest sense, but it’s also not a fully developed browser the same way that Opera itself is. For example, Opera Neon lacks several of Opera’s key features, including a native ad blocker, VPN, and extension support. Further, the developer indicates, “We do plan to incorporate some of [Opera Neon’s] best new features into Opera for computers as early as spring 2017.” So, anyone who uses Opera Neon isn’t beta-testing software so much as they’re beta-testing concepts. We like to call it “beta-esque.”

Whatever you want to call it, Opera Neon has a decidedly different look than other web browsers. When you first launch Opera Neon, you’ll notice it uses your Desktop wallpaper as its own. Front and center are a series of bubbles, which function similarly to other browsers’ Frequently Visited tiles. As you swing by your favorite websites, that site’s “bubble” will rise to the top of Opera Neon’s Home screen. The bubbles are somewhat customizable. If you don’t like a particular site’s ascension to the top of the Home screen, you can banish it by clicking its associated “X.” It then disappears with a satisfying “poof” animation. Less satisfying is the fact that you apparently can’t manually rearrange the Home



screen bubbles. You can, however, shuffle the order of any open “tabs” (in Opera Neon’s case, more bubbles) that show up in a column on the right side of the browser window.

Opera Neon also changes how you use the web. For example, the browser’s split screen mode lets you display two web pages within a single browser window, and you can easily adjust each page’s portion of the window. Sure, it’s not a particular revolutionary addition, especially if you’re already used to snapping two browser windows to either side of your Desktop, but it’s nonetheless a solid feature. Another neat but not quite mind-blowing trick Opera Neon can do is capture screen shots (including a crop tool) of web pages and save them to its internal gallery.

Opera Software puts a big emphasis on Opera Neon’s video capabilities. The centerpiece is its pop-out video feature, which essentially clones a video to a separate window that lives outside of Opera Neon itself. However, this window is bound to the host tab; close the tab or pause the original video, and the pop-out video closes or pauses, as well. Popped-out videos are certainly

Opera Neon 1.0.2459.0

Publisher and URL: Opera Software;
www.opera.com/computer/neon

ETA: N/A

Why You Should Care: Experience the future of web browsing, at least according to Opera.

handy, and we like that the feature is baked into Opera Neon. It’s almost exactly the same as Opera’s pop-out video, though, so you may want to temper your excitement.

Pop the hood, and you’ll see that Opera Neon is essentially the same as Opera, too. It relies on Chromium code and uses the Blink engine, so we weren’t surprised to see Opera Neon deliver the same performance as Google Chrome. We tested both browsers in SunSpider, Octane, Kraken, and JetStream. Chrome outperformed Opera Neon in every benchmark, but never by more than 5%.

Opera Neon’s UI is refreshing, and it’s just as usable as any other popular browser. Even if it’s just a staging ground for Opera Software’s flagship browser, it’s worth taking for a spin. ■

Upgrades That'll Keep You Humming Along

You want to keep your PC safe and secure. We want to keep your PC safe and secure. The majority of our apps featured this month will do just that. We're also spotlighting an alternative to the stock firmware ASUS uses in its wireless routers.

SOFTWARE UPDATES

Cyrobo Software Clean Space 7.04

If you're not satisfied with the program currently assigned to wipe the digital sludge from your PC, why don't you let Cyrobo Software's Clean Space take a swing at it? Windows 10 users stand to gain the most from version 7.04, which adds a pair of options to the app. Now, Clean Space will clean Win10's cache of pinned items, and it can also delete the recently used app history. Torch browser cleaning is new in this update, as well.

<https://www.cyrobo.com>

EasyTigerApps Fused For Windows 10 1.2.3.0

For photos who'd like to have a little fun, Fused is like a party for your images and video. Available for iOS and Win10, the app makes double exposure a piece of cake. Go ahead and layer a video over a picturesque photo background, blend images together, and perform a variety of other cool edits quickly and easily. The headlining feature for the latest Windows version adds Facebook video sharing. EasyTigerApps also includes three new free "Artists Collections"—videos and images from aspiring artists you can mix with your own shots. Version 1.2.3.0 features general performance improvements, as well.

easytigerapps.com

Exiland Backup 4.4

Maybe you only want to use Exiland Backup to keep your data backed up to an external drive. That's fine, but Exiland Backup can do a lot more than that,

backing up files and folders to a variety of destinations (FTP server, networked drives, USB thumbdrives), duplicating the backups, and compressing everything to save space. Released at the beginning of the year, the latest update introduces a handful of minor changes and improvements. Now, a "Detailed Information" option will display each file above the progress bar as it's being copied. Exiland Backup should also be more efficient as it deletes files during synchronization.

<https://exiland-backup.com>

Justmapzz 3.0.1

Contrary to what its name would have you believe, Justmapzz does more than just maps. It can aggregate routes from a number of providers (such as Google, Bing, and MapQuest), display elevation charts (a recently added feature), retrieve weather forecasts for any point on a map, and more. In version 3.0.1, Justmapzz's elevation charts receive an upgrade; now, they're interactive. Click a point on the elevation chart, and Justmapzz will pinpoint it on the map, and vice versa. The update also includes "various interface improvements" and exterminates a handful of bugs.

www.justmapzz.com

NewSoftwares.net USB Secure 2.1.1

For all the emphasis we put on locking down our desktop systems, we don't often give removable media the same treatment. Leave that job to USB Secure, which password-protects USB thumbdrives, SSDs, external drives, and memory cards. The latest update is a small one,

as it fixes a handful of bugs related to the brand-new UI, which NewSoftwares.net introduced a few days earlier in the 2.1.0 release. (That earlier release also squashed some bugs that affected Win10 users.)

www.newsoftwares.net/usb-secure

NoBot 1.0.3.5

A flurry of recent updates helps this malware removal tool (which finds and eradicates bots, RATs, miners, keyloggers, and more) be an even more efficient killing machine. The last two updates—1.0.3.5 and 1.0.3.4—have improved the app's detection capabilities, and version 1.0.3.3 included a new batch of preloaded virus definitions. Version 1.0.3.5 adds "Threat Type" to the Scan tab and fixes a few bugs, while version 1.0.3.4 slightly tweaks Windows file and Registry scanning.

nobotsecurity.com

DRIVER BAY

Asuswrt-Merlin 380.64_2

ASUS uses its AsusWRT firmware, which is based on Tomato, in several of its wireless routers. Don't like it? Swap it for Asuswrt-Merlin. (A list of supported routers is available at the firmware website's About page.) Versions 380.64_2 and 380.64_1 made small changes to version 380.64, which added the ability to alert users to new firmware availability. This feature is actually pretty handy in this case, since the firmware's developer frequently releases updates.

<https://asuswrt.lostrealm.ca>

Super Bowl LI & Tech

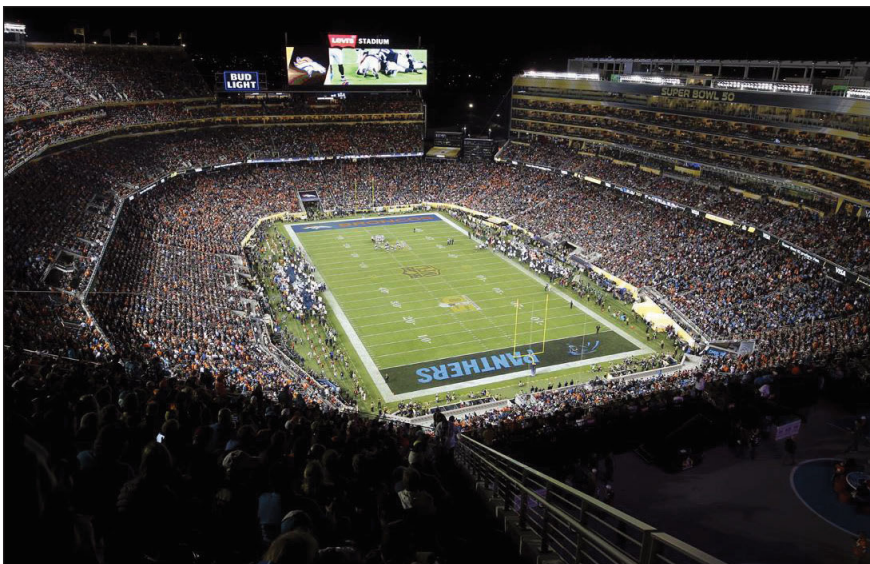
America's Game Gets Fan-Friendly Upgrades

Before and after Super Bowl 50 was played last year in Levi's Stadium in the San Francisco Bay Area, experts cited the game as the most technology-driven Super Bowl ever. Expect that distinction to be short-lived. When Super Bowl LI kicks off Feb. 5 in Houston at NRG Stadium, it's practically a given that technology will make a greater presence, including in terms of wireless connectivity available at NRG, how viewers at home will watch the game, and how everyone will share their experiences socially.

Really, though, technology is altering seemingly every aspect of the NFL and sports in general. NFL-specific examples of how include players and coaches now using Microsoft Surface tablets instead of printed photos on the sidelines to review plays, players adopting VR to improve performance, and the NFL itself spearheading a movement to bolster the wireless networks in every NFL stadium to meet fans' growing "connectivity everywhere" expectations.

"With tickets at premium prices, it's hard to ask fans to pay to spend time in a place where they can't use their phones," says Paul Kapustka, editor of Mobile Sports Report, about the growing importance Wi-Fi, mobile apps, and other technologies have assumed. "For many fans and teams, good connectivity is just table stakes." Among other things, the improvements are making parking easier, helping fans navigate to and around stadiums, and enabling such digital ticketing options as easily transferring tickets to friends or family.

NFL teams are also experimenting with letting fans order food from their mobile devices, complete with in-seat delivery; upgrade tickets and purchase game-day experiences (think live meetups with players); and use stadium-specific apps



At Super Bowl 50 last year at Levi's Stadium in the San Francisco Bay Area, a record-breaking 10.1TB of Wi-Fi usage was recorded. Largely to meet fans' growing in-stadium expectations, the National Football League has worked to upgrade connectivity in all its stadiums.



Prior to this past NFL regular season, Houston's NRG Stadium, which is hosting this year's Super Bowl LI, lacked a Wi-Fi network for fans. For the Super Bowl, 1,260 access points will reportedly be in place to support fans' wireless usage, which essentially has doubled with each Super Bowl.

to view live action, replays, and multiple camera angles. “And don’t forget huge video scoreboards,” Kapustka says. “With the couch the ultimate competition, teams realize they need to make the game-day experience better than ever and are turning more and more to technology to help make that happen.”

And fans are enthusiastically taking advantage. Super Bowl 50, for example, set several records for Levi’s Stadium, including records concerning data usage, unique Wi-Fi users, concurrent users, and peak Wi-Fi bandwidth. The game also generated a reported 4.3 billion views of related content on Twitter and 155 million-plus fan interactions on Instagram, making Super Bowl 50 the most socially shared Super Bowl ever, according to Keith Bruce, last year’s Super Bowl Host Committee CEO.

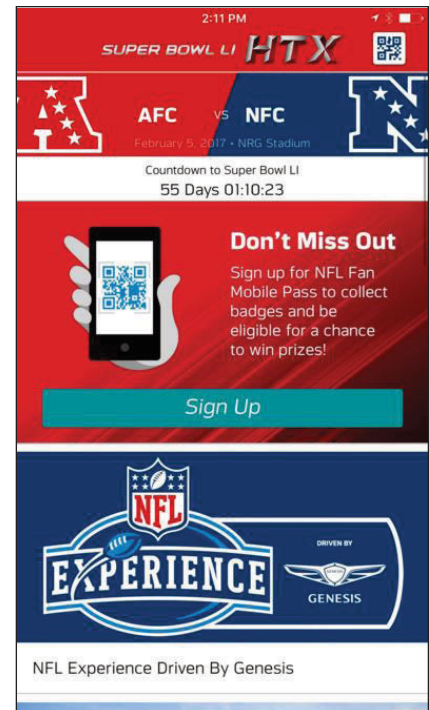
“Technology is everything at the Super Bowl,” says Taylor Bloom, co-founder of SportsTechie. “From the broadcast to connecting fans at the stadium with quality Wi-Fi, the entire spectacle runs on increasingly sophisticated technologies.” Bloom says the Wi-Fi performance in Levi’s Stadium during Super Bowl 50 was the best he’s experienced anywhere.

Further, using the stadium app VenueNext developed for the game, Bloom was able to seamlessly order food and drinks to his seats. “If Houston can simply match the connectivity of Santa Clara from last year, then it will be a successful Super Bowl,” he says.

The New Gridiron

To get an idea of how far the Super Bowl and football in general have advanced technically over the decades, consider that until recently, a fan couldn’t even watch a replay of 1967’s Super Bowl 1, despite NBC and CBS broadcasting the game simultaneously (the only time that’s happened), because the tapes used to record it were erased following the contest. For Super Bowl 50, CBS reportedly utilized 70 cameras, including those integrated in end zone pylons and those part of the groundbreaking Eye Vision 360 system, which essentially stops a replay at any point to sweep 360 degrees around before continuing the replay.

Today, though, you don’t even need to leave the practice field for examples of technology’s increasing influence on football. Take the MVP (Mobile Virtual Player), for example. The



Mobile apps are becoming increasingly important to NFL fans, including in terms of enhancing their in-stadium experience. The stadium app for Super Bowl 50, for example, let fans order food from mobile devices and have it delivered to their seats.

Live & Wireless: The Massive Data Usage A Super Bowl Generates

Sometimes, the numbers say it all. This is definitely true when considering how important wireless access, mobile apps, and technology in general have become to sports teams and fans attending games. Just consider data from various resources related to last year’s Super Bowl 50 at Levi’s Stadium in the San Francisco Bay Area where 71,000-plus fans watched.

According to MobileSportsReport.com, Super Bowl 50’s 10.1TB of Wi-Fi usage in the stadium set a single-day record for a Super Bowl. Comcast stated that equates to 1.2 million photos at 2MB each or streaming 6,000-plus hours of HD video. The 10.1TB bested the 6.23TB recorded at 2015’s Super Bowl. Of the 10.1TB, 9.3TB reportedly stemmed from fans’ usage of the free Super Bowl network. Another 453GB was tied to media usage. Super Bowl 50 also broke records for unique Wi-Fi users (27,316) and concurrent users (20,300). Also impressive is the 15.9TB of combined cellular data MobileSportsReport.com states the four major U.S. cellular carriers saw on their networks in and immediately around Levi’s Stadium during Super Bowl 50.

Interestingly, Comcast documented the top 10 moments responsible for the most data traffic experienced during the Super Bowl at Levi’s Stadium. List toppers included the introduction of 50 Super Bowl MVPs, Lady Gaga singing the National Anthem while the Blue Angels flew over the stadium, the opening kickoff, and the first coach’s challenge. Rounding out the list was fan’s usage of apps to help them return home and to their hotels.

Paul Kapustka, editor of Mobile Sports Report, says there’s always the potential for issues to pop up concerning the new wireless network that was implemented at Houston’s NRG Stadium prior to this season when it experiences the “ultimate stress test” that is a Super Bowl crowd. For years, after all, Super Bowl game-day wireless traffic has essentially doubled each year, and there’s “no plateau yet in sight,” Kapustka says. That said, he says the deployment and equipment teams behind the new network have a good track record for stadium deployments and have had a full season to work out the kinks. “Between them and the NFL’s own tech team, which helps oversee Super Sunday activities, I don’t foresee any issues for the fan networks for Super Bowl LI,” he says.

Pittsburgh Steelers, Dallas Cowboys, and Indianapolis Colts are among eight teams that have tested this \$8,300 practice tool billed as “the world’s first and only motorized, self-righting, mobile training dummy.” Conceived by Dartmouth College football coach Buddy Teevens, the MVP notably never gets tired and can run a five-second 40-yard dash. At 180 pounds, the MVP was engineered to mimic the height and weight of college and pro players. Thus, the “MVP can take a hit” while giving players realistic tackling, pursuit, and pass defense reps without “the impact and fatigue associated with athlete-on-athlete training.” That means less man-on-man contact and risk of injury, including head-related ones.

Another tech-driven practice tool teams have embraced is the HIGHandTIGHT Training Football, a \$170 football that literally whistles when properly held. Meant to help running backs and receivers reduce their fumbles, the ball integrates multiple sensors so that if held incorrectly, the whistling stops. Tom Creguer, the ball’s inventor, told BizTech.com that the ball “teaches muscle memory” and “creates the habit of thinking about ball positioning first rather than running fast and avoiding guys.”

A tech-related effort that doesn’t help improve skills but does offer insight into NFL players’ abilities is the data-driven Next Gen Stats, a research, data,



Through its Next Gen Stats project, the NFL is making various types of research and data available to fans, including fantasy football owners, to dig deeper into players’ abilities and performances.

and analytics platform that captures real-time location data, speed, and acceleration “for every player, every play, on every inch of the field.” Essentially, RF sensors situated in players’ shoulder pads and throughout NFL stadiums help capture real-time game data that teams, broadcasters, fantasy owners, and fans can all dissect and use. This includes via an app for the Xbox One, Surface devices, and Windows.

At NFL.com, Next Gen Stats are available for Passing, Ball Carriers, and Defense categories. Ball Carriers, for example, includes data that details the maximum speed measured in miles per hour that a player reaches on a given play carrying the ball. Longest play data, meanwhile, shows how far a ball carrier traveled during a play regardless of how many actual yards were gained. This season, for example, Next Gen Stats charted Kansas City Chiefs receiver Tyreek Hill

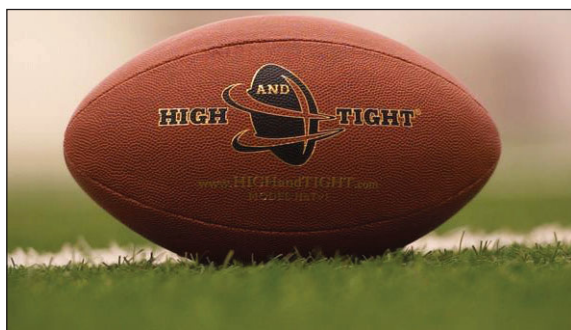
as reaching 23.24mph while traversing 139.37 total yards on a kickoff return.

For Super Bowl LI, Bloom is interested in seeing how such technological innovations can provide fans watching at home with new perspectives into the game’s overall story. “Anything from cameras in the pylons to player-tracking technology that can help broadcasters quantify player performance in ways that were previously not possible highly interests me,” he says. “In the end, sports are content, and the best content comes from great stories. So I’m looking to see how technology can provide new story elements.”

The Road To Game Day

Since 2013, the NFL has been on a mission to enhance the fan experience in every NFL stadium in terms of connectivity, mobile apps, video screens, and other tech-related features. The stadiums that have resulted from the heavy tech investments are “technological marvels,” Bloom says.

As TechRepublic.com points out, the upgrades initially were meant to keep millennials—a generation of users who expect consistently good



Technology is working its way into the NFL in numerous ways both on and off the field. An on-the-field example is the HIGHandTIGHT football, which integrates sensors and emits a whistle to indicate a player is holding the ball properly to reduce fumbles.

wireless connectivity—attending NFL games. Upgrades were also needed to handle the increase in higher-quality images and videos that fans share on social media from within stadiums. Michelle McKenna-Doyle, NFL CIO, told TechRepublic.com that early on, enhancing in-stadium connectivity “was about the tolerance level for our younger fans” and much less about “accessibility and connectivity for other fans. Now, it’s every person who attends a game.”

At Levi’s Stadium, enhancing connectivity meant 400 miles of data cabling, 12,000-plus physical network ports, 1,200-plus Wi-Fi access points, about 1,200 Bluetooth beacons, and a 40Gbps backbone of available internet bandwidth. For the 2018 Super Bowl at the Minnesota Vikings’ new U.S. Bank Stadium, there will reportedly be enough antennas and Wi-Fi access points in place that “all 66,200 fans could theoretically jump on” the network at once.

Historically, Kapustka says getting a good signal at a stadium was impossible. Today, though, most pro sports venues and many large college arenas and stadiums offer high-quality Wi-Fi and enhanced cellular. “It’s always a nice surprise when the basic connectivity exceeds your expectations, no matter where you roam inside a stadium,” he says. “At the NFL venues I’ve been in recently—Levi’s Stadium, AT&T Stadium, and Sports Authority Field at Mile High—coverage is solid across the board on both Wi-Fi and cellular.” Feature-wise, Kapustka says the in-seat delivery services at Levi’s Stadium “were surprisingly fast and welcome, allowing me to watch an entire touchdown drive while waiting for my beer and pretzel, instead of standing in line.”

For Super Bowl LI at NRG Stadium, Extreme Networks is serving as the official Wi-Fi and Wi-Fi analytics provider. Prior to this season, Wi-Fi didn’t even exist at NRG. Reportedly, the company’s wired and wireless solution includes 1,260 access points (including custom under-the-seat APs) located throughout the stadium. The company’s Wi-Fi Coaches program will

have numerous Wi-Fi coaches onsite to assist fans at Super Bowl LI.

John Brams, Extreme Networks director of sports and entertainment, says in-stadium Wi-Fi has gone way beyond a “nice-to-have thing” to become an expectation the same way concessions and bathrooms are just expected. Realistically, he says, the network is there to support what fans do on a daily basis, which 50% of the time is social media. “People want to share their experience and want others to understand what they’re doing in that environment.

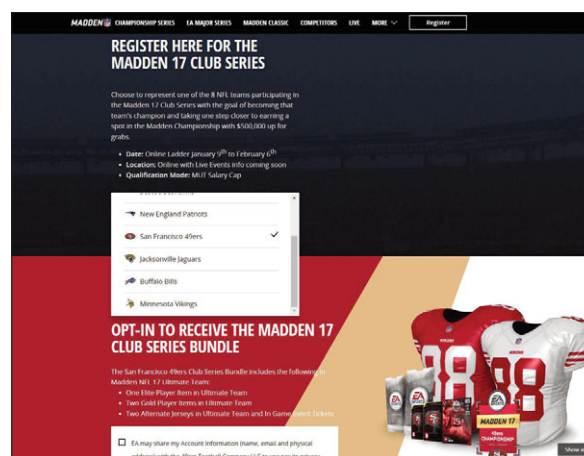
And as a team operator and ownership, they want people sharing their experience in their environment, as well,” Brams says.

Fan demand only ramps up for Super Bowls. At Super Bowl 50, a record 10TB of data passed over Levi’s Stadium’s Wi-Fi network. “Fans come earlier and stay longer,” Brams says. “Everything from a network-capacity perspective ramps up, as well. You get a normal amount of people, for example, taking pictures and sharing those, but think about a Super Bowl experience. You get the pre-game stuff

Madden Gamers Get The NFL Treatment

Where football and videogames are concerned, “Madden” is the word that comes to mind for most. Thus, it makes perfect sense that EA and the NFL announced in mid-December a national Madden 17 Club Series tournament involving participation from eight NFL teams, including the Pittsburgh Steelers, Minnesota Vikings, New England Patriots, Buffalo Bills, Seattle Seahawks, Jacksonville Jaguars, San Francisco 49ers, and Kansas City Chiefs.

Starting in late December, Madden players could select which team to represent in online qualifying ladder tournaments that started in early January, from which eight finalists will move on to club tournaments held at the team’s respective facilities. The Jaguars team, for example, was scheduled to hold its competition at US Assure Club East using NanoLumens LED displays measuring 19 x 11 feet to create a “larger-than-life Madden experience.”



Through its Madden 17 Club Series tournament, EA is giving players the chance to represent one of eight NFL teams in competition. Eventually, eight finalists will compete for \$50,000 in prizes and the chance to move on to the 2017 EA Sports Madden Championship in May.

from each club tournament will advance to the Madden 17 Club Series Championship in April where another \$50,000 in prizes will be on tap. Finalists will also have a chance to qualify for the 2017 EA Sports Madden Championship in May.

At the Club tournaments, the finalists will compete for \$10,000 in prizes (including cash, player-autographed memorabilia, and team merchandise) before live audiences watching via streams on each team’s website and mobile app, as well as the Madden NFL Twitch Channel. Club tournaments will begin Feb. 18 in Minnesota and conclude March 22 at the Chiefs’ Arrowhead Stadium.

Eventually, one winner

with the entertainment going on before the game, the halftime show—that all goes above and beyond the actual football.” Further, Extreme Networks must build out capacity in and out of NRG Stadium to accommodate media requirements.

Extreme Networks began its work about 18 months ago. Planning has notably included preparing for the unknown. “We’re still in weekly meetings in partnership with the NFL, stadium operations people, and our partners in this project, making sure we’re counting for the unknown,” says Brams, who points to the roughly 30-minute power outage that occurred during 2013’s Super Bowl XLVII as an example.

Reality Sets In

One thing that’s certain about every Super Bowl is that one team will win and one will lose. Another is that every Super Bowl makes for big business and big viewing. Last year’s Super Bowl attracted 111.9 million television viewers, for example. The post-game show itself attracted 70 million, making it the second-most-watched telecast for 2016. In terms of business, beyond the ad dollars generated, the Super Bowl helps move a lot of television sets. Consumer Reports notes that stores discount units 22% on average in the weeks prior to the game, with deals tending to “favor crowd-pleasing large-screen sets.” This year, experts agree it’s larger 4K sets football fans are eying.

Last year, Japanese State broadcaster NHK actually used 8K cameras to broadcast Super Bowl 50 in 8K Super-Hi Vision (16 times the resolution of HD). 4K.com reports NHK specifically used Ikegami SHK-810 cameras, which house a 33-million-pixel Super 35mm CMOS sensor. While the 8K broadcast was only viewable within Levi’s Stadium and at NHK’s Tokyo-based headquarters, broadcasting the game in 8K was part of bigger plan to air public 8K live broadcasts in time for the 2020 Olympic Games in Tokyo.

Increasingly, other technologies are joining the television as visual options for fans to view football. During this

The Bumpy Reception For Microsoft Surface Tablets

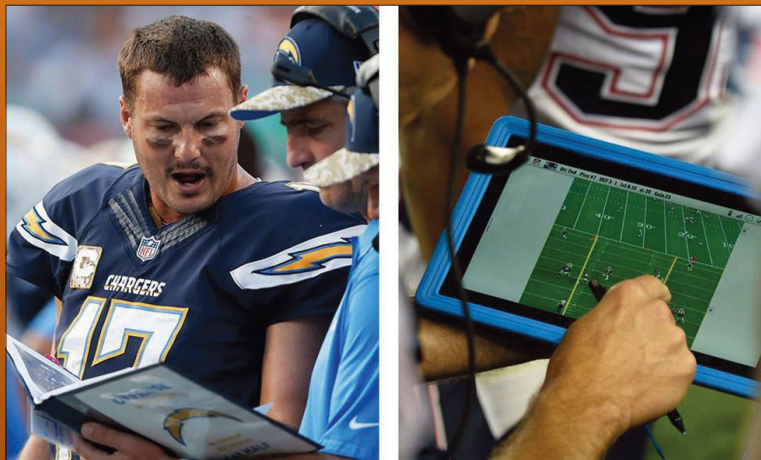
When the NFL and Microsoft inked a five-year \$400 million deal in 2013 to put Microsoft Surface tablets on NFL sidelines to use during games, the arrangement seemed a no-brainer. After all, tablets promised to eliminate the hassle of printing photos for players and coaches to review previous plays while simultaneously introducing greater speed, efficiency, and versatility. Not everyone has been a fan, however, including Bill Belichick, arguably the NFL’s greatest coach ever.

Despite the advantages, some coaches and players have voiced complaints about tablet dependability. Such a claim came after last year’s AFC Championship game between the Denver Broncos and Belichick’s New England Patriots when the Patriots’ tablets malfunctioned for several minutes during a key touchdown drive by the Broncos, who won the game 20-18. Belichick later depicted such malfunctions as being “fairly common.” The NFL and Microsoft maintained network issues were to blame and not the tablets.

Belichick never did become a fan. In October, he said the tablets were “too undependable” and he’d be sticking with photos, “which several of our other coaches do, as well, because there just isn’t enough consistency in the performance of the tablets.” Days later, Yusuf Mehdi, Microsoft corporate vice president, Windows and Devices Group, acknowledged the debate but pointed out that prior to tablets, “coaches and players pored over stacks of static, black-and-white photos,” meaning “someone had to take the images, send them to a printer, wait for black-and-white prints, grab them from the printer, and work to stick them in a three-ring binder” before delivering them to the sidelines.

Conversely, Mehdi stated tablets enable teams to “respond nearly in real-time,” including with “dynamic, full-color images, up to seven times faster than the printed page. Game analysis is more efficient, productive, and competitive—enabling quicker decision-making by coaches and players, in a game often decided by inches and seconds.”

Elsewhere, The Ringer detailed other issues coaches and players have with tablets, including one related to the digital playbooks players now receive on tablets. One worry is players are missing “major details” by relying too heavily on technology and could experience an “information overload” leading to “paralysis by analysis” setting in.



While some coaches and players have voiced complaints about the dependability of Microsoft Surface tablets, their use on NFL sidelines has also been credited with greatly enhancing how players and coaches can now review plays during games.

The Modern Ways To Watch Super Bowl LI

When the opening kickoff for Super Bowl LI sails through the air in Houston's NRG Stadium Feb. 5, 72,000 or so fans will see it live. The rest of us (meaning 110 million or more in the United States alone) will have to find another way to watch. There will be many options.

Most people will simply catch Fox's national broadcast in which Joe Buck and Troy Aikman will call the game. Fox will also provide a live, free stream on Fox Sports GO without any need for users to authenticate. Overall, users can watch via iOS, Android, Windows, and Amazon devices and via Apple TV, Roku, Chromecast, Amazon Fire, and Xbox One connected devices. Notably, Fox is working with 170-plus affiliates to sell and deliver local digital ads for the stream in addition to showing the national ads many people specifically watch Super Bowls to see. Last year, CBS' stream of Super Bowl 50 reportedly averaged 1.4 million viewers per minute and 3.96 million unique streams total.

For cord-cutters and cord-nevers, connecting an over-the-air antenna to a television to pick up Fox's signal is an option, as is acquiring a Fox-included package from Sling TV, PlayStation Vue, or DirectTV. NFL Game Pass subscribers can watch the game on-demand after it originally airs. If all else fails, there's Westwood One's national radio broadcast.

In the stadium, fans won't be hurting for screens to watch live action, replays, and more. NRGpark.com states the seating bowl area alone features two end-zone scoreboard displays, with each end zone including a video LED board and four lamp-matrix displays; one 360-degree LED Fascia display; two LED Fascia displays; two game-in-progress scoreboards; and a field-lighting array that includes "480 optically enhanced luminaires with more than 65,000 LEDs." Each concourse and club area, meanwhile, sports an HD LED video board and four HD video projection screens. Overall, there are 1,550-plus HD LCD flat screens in the stadium's public areas.

NFL regular season, for example, Twitter live-streamed 10 Thursday Night Football games, with later ones ranging in viewership from 2.6 to 3.1 million. Moving forward, expect VR and AR to also have a greater impact on the game.

Already, the NFL plans to begin using VR simulators and POV cameras to help train referees. Through partnerships with NextVR and Voke, meanwhile, the league has been producing highlight packages fans can watch free in VR. NextVR, for example, teamed with NFL Films to offer highlights for three games in late November and December. (NextVR is also broadcasting 25 NBA games in VR this season available via the NBA League Pass.) Voke also worked with NFL Films to offer highlights for four games in December and early January.

The NFL also partnered with Google on a nine-part series filmed in 360-degree VR using Google's Jump system. Available for viewing using Google's Daydream View headset, the series debuted Thanksgiving Day on the NFL's YouTube channel. Intel, meanwhile, recently announced plans to use its 360-degree replay technology at Super Bowl LI via a "Be The Player" campaign featuring New England Patriots quarterback Tom Brady. It's being billed as the "football fan's ultimate dream." Intel will reportedly use nearly 40 5K cameras to help Fox replay about 20 big plays in 360-degree glory. Each replay reportedly consumes about 1TB of data.

Moving forward, Bloom says VR and AR could be heavily involved in the at-home experience for fans. "The Super Bowl is one of the most social viewing experiences for any sports fans. Therefore, VR will not penetrate the Super Bowl viewing experience as much as AR will," he predicts. "AR can be presented in someone's living room, and everyone in the room can interact with it at once to enhance the experience." VR, though, isolates a user into his own reality, Bloom says. Even if a VR solution emerges that lets viewers collectively view an event, Bloom doesn't see it "surpassing the experience of having 20 friends enjoying each other's company and sharing good food during the game."

Because the Super Bowl is also an advertising event, Bloom foresees a scenario one day where advertisers use a device or fans' smartphones to project Super Bowl ads into a living room. "As for the in-stadium experience, I'm again more bullish on AR than VR. AR could enhance the Super Bowl halftime show or action on the field more easily than placing someone in their own virtual reality to experience it when they are already there in person," Bloom says.

According to CRN.com, New England Patriots President Jonathan Kraft recently hinted at potential AR features fans might experience in Gillette Stadium, including accessing AR via smartphones or glasses. Fans, for example, could "look through the phone or glasses and see the 22 players on the field and above them a little cloud seeing who that player is and letting you know anything pertinent you want to about them," Kraft stated.

Kapustka says AR and VR could eventually become part of the fan's game-day experience, though he believes it will likely happen in a separate area, such as a lounge or club. "The ability to bring live VR content to seats via Wi-Fi is many years in the future because right now, there's way too much bandwidth needed to generate VR content—a load Wi-Fi networks of today simply can't handle in crowded places," he says. "I think VR and AR broadcasts may end up being something more popular on the couch than in the stadium. It's hard to cheer and high-five the person next to you if you're stuck inside a VR headset."

Eventually, Kapustka foresees features already being used in television broadcasts, such as a player's biological stats or the speed he's running, coming to stadiums either on big screens or on an AR display. "Fans love this kind of information, and if you can make it happen in a way that's not claustrophobic, my guess is it will be very popular," he says. That said, Kapustka says the biggest issues people still have with attending live events "are simple things like traffic, parking, and waiting in lines. Technology still hasn't been used well enough to make those things go fully away." ■

CPU

Game Of The Month

Yeah, we know you have blogs to post, video to encode, reports to write, and code to compile. We do, too, but you have to take a break once in a while (and maybe blow some stuff up). That's why each month we give you the lowdown on what to expect from the latest interesting games.

RESIDENT EVIL

biohazard

Longtime fans of survival horror videogames know that although there were one or two precursors, Resident Evil was the game that kicked off the popularity of SH games in earnest in 1996. Those same fans also probably know that for many years, alternating releases of Resident Evil games and Silent Hill titles were the tentpole launches that continued to fuel gamers' appetite for scary games, which eventually led to the proliferation of horror-themed games that we enjoy today.

Over the years, however, the Resident Evil and Silent Hill series diverged considerably in theme and content to the point where they were more like members of two distinct genres than entries in the same one. This began especially with the arrival of Resident Evil 4 in 2005; RE4 was a great game, but it was more of an action shooter with elements of horror mixed in here and there, and that trend continued with the releases of Resident Evil 5 and RE6. Silent Hill, on the other hand, mostly stayed true to its survival-horror roots, creating atmosphere with oppressive, creeping dread more than with automatic weapons and truckloads of ammo.

Earlier this week, Capcom debuted the latest entry in the Resident Evil saga, Resident Evil 7, and the game is notable for a couple pretty big reasons: For starters, it is the first major release in the series to shift the player's perspective to full-time first-person, and second, it's very clearly a return to the basic principles of survival horror: creepy environments, terrifying opponents, and extremely limited resources.

In RE7, you play the role of Ethan Winters, a regular guy whose wife Mia left home three years ago and never came back. The game opens as you drive to a dilapidated plantation out in the bayou in Louisiana in response to an email that arrived out of the blue from your wife, asking you for help. Although

The King Is Back

BY CHRIS TRUMBLE

\$59.99 (PC, XOne, PS4) • ESRB: (M)ature • Capcom
residentevil7.com

the old place is crumbling with decay, it is not vacant, and you very quickly encounter the Baker family, several people who are at best stark raving mad; it's hard to say what the worst-case scenario is.

As Ethan, you must run, fight, hide, and solve puzzles to survive and to piece together the story of what has happened here to your wife and to the Baker family, not to mention the many travelers they have waylaid and who subsequently disappeared. You have access to a few weapons, but you will not find the ammo you'd need to go into every enemy encounter guns blazing—often, avoiding your foes is the best policy. RE7 also drops you into a number of boss fights at pivotal moments, and in these situations there are often more expedient ways to win than just shooting a lot, providing you can recognize and execute them (pun intended).

Along the way, you'll collect keys for specific rooms, find herbs to heal your injuries, and enjoy other Resident Evil gameplay staples. The game is built on Capcom's new RE Engine, and although there are a few uncanny-valley issues with the game's characters, they generally look pretty good, and the environments are masterfully done. We played the Xbox One version, but it's also available on PC and PlayStation 4. (The PS4 version is PS4 Pro- and PlayStation VR-compatible.)

This game is not for the faint of heart, as no horrific stone is left unturned throughout your journey. You'll hear terrifying sound effects, witness mind-bending acts of violence, experience jump scares, find creepy videotape messages, and wade through buckets of gore. But although the game has some flaws in mechanics and execution here and there, it delivers a superbly scary experience that no survival horror fan should miss. ■



SPACE HULK DEATHWING

In the grim darkness of the far future, there is only war. But for now, there are also some really fun games based on Games Workshop's immensely popular Warhammer: 40K universe, and Space Hulk: Deathwing from Focus Home Interactive is one of them.

Those familiar with the Warhammer 40,000 premise will recall that space hulks are sort of like the interstellar equivalent of our oceanic garbage patches, except that instead of consisting of bottles and cans and the like, they are made of ancient derelict spaceships that were lost long ago in the immaterium. These twisted amalgamations of old ships are occasionally ejected from the warp for various reasons, and when they enter real space, they cause big problems, as they are ideal breeding grounds for Tyranid Genestealers and other (also terrible) things.

The very first Space Hulk game was a board game issued by Games Workshop in 1989, and since that time there have been a handful of videogame adaptations of that concept. Deathwing is the latest, drawing upon both the old Space Hulk lore and that of the Dark Angels, a Space Marine chapter steeped in mystery and betrayal. The Deathwing is the Dark Angels' elite first company; in the game, Deathwing leader Grand Master Belial dispatches the company to intercept a space hulk that has entered real space and purportedly contains an ancient Dark Angels warship lost nearly 10,000 years prior during the great Heresy.

Long story short, the game is a first-person shooter that puts you in the role of a Deathwing Librarian, a superhuman psychic warrior

Purge The Xenos

BY CHRIS TRUMBLE

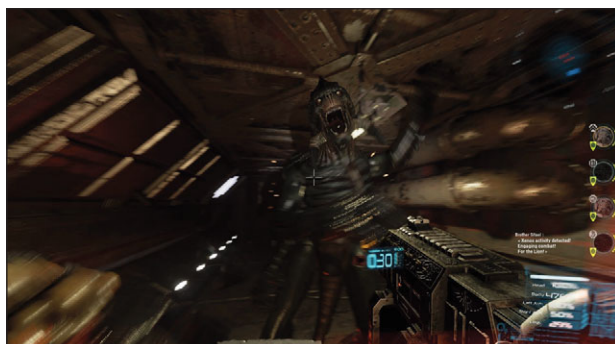
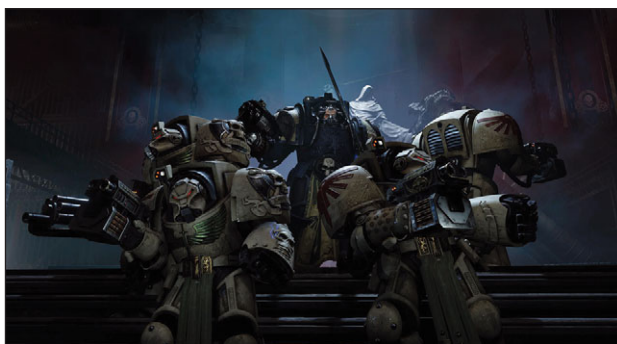
\$39.99 (PC) • ESRB: n/a • Focus Home Interactive
www.spacehulk-deathwing.com

with incredibly powerful armor and weapons. You have a squad of Deathwing Terminators at your disposal, and you have to fight your way through the hulk to the Dark Angels ship to unlock its mysteries.

The campaign portion of the game has some simple squad control elements, and you start out with just a couple of basic weapon options and a couple of basic (but very cool) psychic attacks. As you complete missions and discover ancient relics, you and your squad mates will have access to more advanced weaponry, which you can select before missions and during them when you use a psychic gate to jump back to your base of operations. There's also a four-player co-op mode that lets you and your friends select your own classes and customize your loadouts to take on the dangers of the space hulk as a team.

At launch, the game had significant problems with bugs that in some cases could even break the game and cause you to have to restart from your most recent save point, but many of these have been ironed out with a patch that dropped Dec. 21.

There are still some issues; squad AI isn't as good as it could be, and some of the menus and especially the map screen are wonky and frustrating. But the core gameplay is very solid, and both the characters and the environments look like they were ripped right from the pages of your favorite Warhammer 40K novels. Deathwing does a nice job of making you feel like a massive Space Marine Terminator. The game doesn't do a lot of hand-holding for those who aren't familiar with the universe, but if you're a fan, this game is a must-play experience. ■





ASTRONEER is a planet and space exploration game that's currently in pre-alpha on PC and Xbox One. Although it's rare that I review games that are unfinished, I decided to take a chance on this one because I'm a sucker for space, and January is such a wasteland when it comes to new game releases. I'm happy to report that ASTRONEER scratches the same itch as another unfinished indie game I took a chance on, called Minecraft.

ASTRONEER opens with your space-suited character seated in a pod and blasting from the EXO Dynamics space station to the nearby planet. You are a 25th-century pioneer, and there's a wide universe of procedurally generated planets available for colonization, exploration, and valuable mineral harvesting. You need but land, stake your claim, and survive to reap the rewards.

Your pod becomes the central hub of your base, and it'll sprout arms and new modules when fed the right resources. These modules include a printer for creating batteries, solar panels, generators, and fuel cells; a trade platform for exchanging your glut of mined resources for those hard-to-find elements you need to craft the next item on your list; smelters for turning ore into usable metals; research modules for turning enigmatic discoveries into useful equipment; and a vehicle bay for manufacturing rovers, trucks, shuttles, and spaceships for expanding your sphere of influence.

When you're near your pod, oxygen and energy are infinite, and you can run around freely mining and reshaping the landscape using your all-in-one matter manipulator. I'm borrowing that term from Starbound because it's better than the official "deform tool." With it you can dig



Manifest Destiny In Space

BY ANDREW LEIBMAN

\$19.99 (PC, XOne) • ESRB: (E)veryone • System Era Softworks
astroneer.space

holes, collect resources, and harvest organic material using the Lower Mode; or use the Raise Mode to create mounds, bridges over chasms, fill in holes, or point it at your feet to give yourself a higher vantage point. There's also a Level Mode that acts like a smoothing function.

Once you step too far away from your pod and its tentacular modules, however, your suit's oxygen tank begins to empty and your matter manipulator taps into your suit's very limited energy reserves. To explore farther afield, you'll need to put down tethers that keep your O2 and energy topped off, and it won't be long before you'll need to venture into the unknown to gather more and rarer resources.

With its pinkish, yellowish, purplish screenshots, space themes, and the procedurally generated buzzword in tow, you might think ASTRONEER bears more than a passing resemblance to No Man's Sky. But by releasing early, ASTRONEER is avoiding all the major missteps of NMS. While it does feel like there are pieces of the puzzle still missing, ASTRONEER is fun to play and it's still delivering surprises more than 15 hours in. Best of all, it's just \$20, and it supports up to four-player multiplayer.

I played ASTRONEER like I played Minecraft when I first encountered it as a plucky indie title, by going in blind, sans wiki. The game's inventory needs work, it plays much better with a mouse and keyboard, and there's a definite sense that one could easily become stranded without a way back to safety. It can be frustrating at times, but as long as you accept that mild frustration is to be expected when trying to colonize an alien world, you'll have an absolute blast. ■



URBAN EMPIRE

BE A MAYOR PLAYER

Gamers have been building and running cities since 1982, when Don Daglow's *Utopia* established the genre. Of course, seven years later city builders really rose to prominence in 1989, the year Maxis introduced the granddaddy of them all, *SimCity*. Dozens of city builders have come and gone since then, and although they've steadily grown more intricate (often allowing you to drill down to the thoughts, desires, and ambitions of individual citizens), the basic objectives haven't changed much.

Urban Empire, the work of Finnish developer Reborn Games, doesn't want to be known as a city builder. Instead, it's a "city ruler." Sure, you build, but it's a mostly hands-off process. *Urban Empire* instead focuses on the politicking necessary to successfully run your city. As your city develops, the game not only requires you to deal with all sorts of difficulties that typically affect a town but also pits you against political rivals to outmaneuver. It's no wonder that Kalypso, which publishes the popular island sim *Tropico*, scooped up this game.

From the jump, *Urban Empire* presents you with options, options galore. You start by choosing from one of four political families, each with attributes that provide specific bonuses to your bottom line, to start and rule over a new town in the fictitious European country of Swarelia. The campaign begins in 1820 amidst the Industrial Revolution, and as you'll quickly learn, the technology in *Urban Empire* is just as pivotal as the politics.

Urban Empire has a distinctly Eurocentric feel to it. In most regards, locating the game world between Austria and Italy (per Kalypso's blog) matters little. Buildings are buildings, and streets are streets. However, when it comes to the game's political parties, this Yankee admits that it wasn't always easy to keep track of what each faction wants. ("OK, now who are these guys in the Free Democratic Party, and exactly how free and/or democratic are they hoping our little burg will be?") I learned quickly, though, because for as much as *Urban Empire* wants you to believe that you're the boss, almost *nothing* happens without the say-so of your city council.



Mo' Mayor, Mo' Problems

BY VINCE COGLEY

\$39.99 (PC) • ESRB: Rating Pending
Kalypso Media • www.kalypsomedia.com

Urban Empire kindly gives you the option to begin a campaign in tutorial mode, which is something I highly recommend. The actual building process essentially consists of drawing a district, allocating its zones (residential, commercial, industrial), and deciding whether to include infrastructure (gas, electricity, etc.) and public services (schools, clinics, police stations—a rare opportunity to actually place structures where you want them). Your town then grows itself; homes and businesses automatically spring up, requiring almost no input or guidance from the player. The first district is "free," as far as spending political capital goes, but be prepared to throw down at City Hall when it's time to expand. Want to make changes to an existing district? That'll require—you guessed it—another vote.

Amping up the political aspect of building and running a city is definitely intriguing, so it's a little disappointing that *Urban Empire* delivers very little intrigue. Yes, you can blackmail and bribe certain council members, and the game's multiparty system is unlike anything you can expect to encounter in American politics. However, too often votes boil down to "Is there enough cash in the city treasury to afford this?" as opposed to real political wrangling.

In truth, *Urban Empire* shines brightest when it channels Nikola Tesla instead of Boss Tweed. Reborn Games clearly spent a lot of time constructing the game's tech tree and keeping it reasonably consistent with technological and social trends as they've developed over the past two centuries. Encouraging innovation has a positive payoff for your citizens, but actually implementing new technologies has a price tag. I should note that you can use your family's wealth to finance development, but once you zero out your own bank account, be prepared to do some more political panhandling.

The variety of architecture in *Urban Empire*, and how it changes through history, is also laudable. Ultimately, Reborn Games has created an interesting spin on a classic genre, but *Urban Empire* needs more soul, perhaps a sense of humor, and an even stronger executive branch. ■



Q&A With John Titlow

The State Of Streaming Music Services

You only need to let a few findings from a January-released report from BuzzAngle Music sink in to understand the significant shift the U.S. music industry is undergoing. While overall consumption of music rose about 5% between 2015 and 2016, consumption of audio streams climbed a whopping 82.6% to reach about 250 billion streams in 2016. Arguably more important, the percentage of overall streams tied to paid music subscription services (Apple Music, Spotify, Tidal, etc.) reached 76% in 2016, up from 62% in 2015. Conversely, physical album sales (down 11.7%), digital album sales (down 19.4%), and overall album sales (down 15.6%) all fell in 2016. In fact, audio streams on an average day in 2016 topped song sales for the entire year (734 million).

Despite the encouraging growth for paid subscription streams, concerns still exist. For the music labels, there's an issue concerning the difference in payouts artists see from subscription services compared to those from free, ad-supported options such as Spotify's free listening tier. For subscription services, there's still a matter of turning a profit, something the major players reportedly have yet to do. John Paul Titlow has covered the music-technology sector for years, including for *Billboard*, *Noisey*, and *Esquire*. A musician himself, Titlow recently detailed for *Fast Company* seven ways the streaming music industry will change this year. One prediction calls for at least one major service not surviving the year. We spoke with Titlow about the impact music streaming is having on the industry; how home speakers/digital assistants such as the Amazon Echo could alter consumers' views about paying for music; the growing importance that playlists are assuming; and more. (You can read our entire interview at www.computerpoweruser.com/24058)

Q: Until relatively recently, some people wondered if the music industry as we've known it would be around much longer. Now, some people are saying music streaming has given the industry new life. Where do you see the industry?

JT: In general, I'd say overall there are reasons for promise, and there are reasons to be uncertain. Overall, music consumption is increasing. I think we saw an almost 5% increase in music consumption overall in 2016. That's according to BuzzAngle Music, which just put out a report. Of course, that's driven largely by streaming. Audio streaming reached a new high, something like 250 billion streams last year. So clearly people are listening to more music. Sales of physical albums have been declining for quite a while, but we've reached a point in the past year or two where the record industry is finally able to report



some growth after years and years of decline. I think from its vantage point, things are starting to turn around, but again, there are multiple players in what we can call the "music industry" today. There are questions around whether

that growth trickles down to artists. In some cases it does. If you're a big-name artist, you're seeing some real money now from streaming. But if you're a smaller, independent artist or a mid-tier artist, you're still wondering how this is all going to play out for you. You might land on a Spotify playlist and see your plays go through the roof, and you might generate some interest and that might help you plot your tour or something like that, but the bigger question continues to loom of how does this new kind of music economy ultimately fare for especially the smaller and middle-class artist?

I will say that there seems to be a growing emphasis on the part of the streaming platforms to cater to the needs of artists, or at least try to. Pandora is busy reinventing itself as we speak, but you can tell from its acquisitions at the end of 2015 of things like Ticketfly and Next Big Sound that it's focused on that, and I think it's kind of in its DNA

with folks like Tim Westergren [Pandora founder and CEO], who was a musician. Whether that works out for them we'll see, but that's definitely a motivation for them. Spotify last year hired Troy Carter [as global head of creator services] and is putting a heightened level of focus on serving artists and the creative community. And this is a crucial thing of course. There are those looming questions about how artists fare in the streaming world, and of course, Apple and Tidal are both known for doling out presumably very large sums of money for exclusive deals with artists. With Tidal specifically—even though it's smaller than Spotify and Apple—a chief focus of theirs is trying to be more artist-friendly.

Q : The terms “music streaming” and “subscription music services” often get used interchangeably. Can you touch on the differences that actually exist between the two and why the music industry is particularly excited about the latter?

JT : From the consumer standpoint, they might not seem that much different, but you're either paying for one or not. If I'm a listener and I say, “I subscribe to Spotify,” I might also jump over to SoundCloud or YouTube for other things. From the industry standpoint, there's a big difference there, of course. Because getting people to pay \$10 a month for access to music just generates more revenue than advertising-supported free streaming of the sort you see with YouTube and Spotify.

Probably some of the confusion you see comes from Spotify, which is a paid service that also has a free [ad-supported] tier. The industry likes where things are going with the paid version. They're not so happy about the free tier. That's been a big sticking point for a few years. That's why folks like Taylor Swift are critical of Spotify. But from the industry standpoint, it's quite a different thing because one generates more money than the other, and I think there's a growing restlessness on the part of the music industry to close what they call

the “value gap.” There's a huge explosion with streaming overall, and a lot of it is paid subscriptions, which is great from their vantage point, but there's still quite a lot of it that is YouTube, that is Spotify's free tier, that is SoundCloud. If you're a consumer, it's great. You can find just about everything in the world between those services. But if you're the music industry, you're getting a little bit frustrated with the fact that one just pays out a lot more than the other.

Q : Can you expand on the difference in revenue that paid subscription services generate compared to what is generated by ad-supported music streaming options such as Spotify's free tier?

JT : Really, it almost comes down to simple math. With paid subscription services, it's a much more clear-cut formula. If you get people to pay—at this point, it's typically \$10 per month—for access to music as opposed to bringing in ad revenue from that music—with rates that are simply lower, those are per-stream rates—I'm not sure what the latest numbers are, but they just don't add up to the same amount. When you get into stuff like YouTube, I think the labels are especially frustrated because YouTube is user-generated, unlike Spotify's free tier, for example. There's just a lot on YouTube that either isn't being monetized or isn't being monetized the right way. YouTube has worked very hard to try and build tools to help with that. The content idea is all about trying to help rightsholders monetize or take down or whatever they want to do with content uploaded to YouTube.

You almost forget because YouTube is primarily a video service, but it's an enormous source of music, as well. And you've seen YouTube try and formulize that a bit last year with YouTube Red and even its music app, which are promising steps, but YouTube is still pretty much synonymous with free content, and a lot of that content is music. And it's being supported with ads, but again, the ownership of the content is not always

clear. Some of it's up there and it's getting monetized or someone else is monetizing it. They're figuring out various ways to improve that, but, again, the end result is a certain amount of content on YouTube is not generating revenue for the artists and songwriters and the labels. There is an enormous part of it that is, but even on a large scale, those ad rates either generated by YouTube or Spotify's ad-supported tier just don't add up to being the same as if you have someone's credit card, they've committed to subscribing, they're going to renew every month, it's \$10, and you know it's just going to be there. So far, the ad side hasn't come close to catching up.

Q : Some insiders believe that music downloads may go away in coming years, essentially because people are willingly shifting from wanting to own music to being OK with renting it. Do you see such a fate for downloads?

JT : I think people still do want to own music, but I think digital ownership becomes sort of an odd concept when you're almost renting digital access. What I think you do see are some upward numbers in the physical album market. They're not enormous, and I don't think they're going to catch up with streaming, but vinyl tends to have an uptick. Last year, even cassettes had an uptick around the holidays. So I think people who really love music still have an interest in owning, especially physical albums. Albums they really love. I do think we are moving to a world where something like 90% of the music listening that most people do will be from streaming. You're going to see fewer and fewer downloads.

It really comes down to Apple. There's a rumor it's going to stop selling downloads at some point, which it denies. But at a certain point, if it's making a certain amount of money from Apple Music, it might not even make sense to run the iTunes store. Or maybe iTunes becomes, I don't know, a place to get albums outside of the scope of the streaming library.

Q: You've mentioned the idea of people regarding music as a "utility." You've also written about the impact that smart home digital assistants/speakers could have on music streaming. Will devices like the Amazon Echo lead more people to view music as a monthly utility they're willing to pay?

JT: I haven't seen data on this, but you have to imagine that with the pretty substantial success of the Echo and other Alexa-enabled products—then the

a device in your pocket at all times or you might have a car that can connect to these services, but there's just something about having it in your home. This is something that Sonos has kind of been angling at for quite some time. And it has responded to the popularity of the Echo, as well, by kind of, like everyone else, working to add Alexa voice control into its speakers.

These things are taking off, it seems pretty quickly, and I can imagine that if we reach a point where it's a mainstream thing to have this smart connected

artists for expanding fan bases. Has the playlist taken on increased importance?

JT: For sure. As these platforms have grown and they've each put more and more emphasis on curation and building playlists, you end up with a situation where you have millions of people listening to some of these playlists. In a lot of ways, it's kind of like the new radio in a sense. I mean radio is still radio, but this is a lot easier to penetrate. If you're an artist at almost any level, if your music is on the service and comes across the radar of the person building the playlist or the algorithm building the playlist with something like Discover Weekly [on Spotify], then all of a sudden you can find yourself alongside much more recognizable names and getting a really substantial boost in exposure.

I've talked to artists who have come out with a new album and a song lands on some genre-appropriate playlist or mood-appropriate playlist even—there are so many ways to divvy these things up—but they see enormous activity suddenly around their catalog. So it's become a major force. It's now like pitching the playlist at Spotify has almost become like the new version of sending your demo tape into the radio station. It's just that in this case, it's much more likely to get on one of these playlists.

I remember talking to Troy Carter at Spotify about this. The odds of landing on one of these playlists is much greater because there are so many of them, and they're divided up in so many ways, by genre, by era, by mood, by all kinds of things, or, again, by algorithm, by collaborative filtering, by people who like similar things and this logic, it makes sense it's more accessible than radio. It might not have the same impact as getting your song on a Top 40 radio station, but it will get your music in the ears of roughly the right people, depending on the playlist. It obviously has the attention of the labels and the artists. I think they're seeing now that if they land on one of these playlists, it really does pay off. ■

It might not have the same impact as getting your song on a Top 40 radio station, but it will get your music in the ears of roughly the right people, depending on the playlist.

rush among the competitors to launch often quite similar-looking products like Google Home, and then there are rumors that Apple is working on one—this whole idea of this AI-fueled, personal-assistant, smart speaker is a category that I don't think most of us really imagined as existing or even really wanting a couple of years ago. But it's here, and it seems to be huge.

I think if you look at the success of those things—Amazon isn't totally open about its numbers—that they're doing well. Once you have a device in your home that enables you to very, very seamlessly, without a screen and without even that much thought, to start piping music into a room, the whole idea of music as a utility starts to make a lot more sense. I mean it makes a certain amount of sense, too, that when you have

speaker in one or multiple rooms of your house for people who may not have considered it before, it makes a lot more sense to pay a monthly fee for music. It's interesting, there was a book that came out like 13 years ago called "The Future Of Music." They called it a "manifesto for a digital music revolution." That was back in 2005, sort of before you even had the iPhone or Spotify or anything. They talked about the concept of music like water, or basically a utility you paid for. At the time, it sounded sort of like science fiction, but that's exactly where things seem to be headed.

Q: Another interesting trend is that playlists are becoming increasingly important to consumers for discovering music and to the music labels and

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www.lanreg.org/pdxlan/pdx29

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www.critgamer.com

02.17-19.17

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pong.uwstout.edu

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MidWestLAN2017: Arctic Warfare
Middleton, WI
midwestlan.com

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ETSU-Con LAN
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kcgameon.com

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www.wichitalan.com

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lanoc.org/lan-parties

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SanDiegoLAN.net/LANaThon.html

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Q&A With Andreas Rudnicki

Alphacool's CEO

On The Eisbaer Cooler Series

Q: So, Alphacool just launched the Eisbaer family of all-in-one CPU coolers, with four models. How did you pick the name? "Eisbaer" translates to "ice bear," right?

AR: The name "Eis" ("Ice") denotes our high-end product series. At this point, we have whole product families under the name. Connectors, HardTubes, pumps, reservoirs, and much more. Everything starts with "Eis." An "Eisbär" (polar bear) is an emblem of the North and stands for power, cold, and endurance. We've found that this fits our AIO coolers very well, since they have all these characteristics. A perfect name for a strong product.

Q: Obviously there are a lot of closed-loop CPU liquid coolers on the market. What did Alphacool do with this latest line of coolers to make them stand apart?

AR: We have a truly integrated reservoir which is also refillable. We use classic 11/8mm connectors with the standard G1/4-inch threads normally used in the DIY world instead of cheaper custom connectors. We have also developed a unique new pump, which



is available separately as well as in the AIOs from be quiet! and Fractal Design. This pump is one of the quietest on the market.

Q: What made this the right time for Alphacool to introduce an all-in-one CPU liquid cooler?

AR: We first wanted to optimize our pump and quick-lock

connectors and bring them to a level where we ourselves were satisfied with them. We also wanted to complete the development of our new CPU waterblock in order to incorporate its improved technology into the Eisbaer. The XPX Eisblock is currently the most powerful CPU DIY waterblock on the market. Furthermore, the spread of cheap steel or aluminium radiators is still a thorn in our side. We have always stood firmly by our full-copper radiators, which perform substantially better and have no corrosion issues that would need to be prevented with lots of chemicals.

Q: We'd like to know more about the Eisbaer coolers' quick-release mechanism; why did you add that, and what do you envision Eisbaer users doing with it?

"... the spread of cheap steel or aluminum radiators is still a thorn in our side."

AR: We wanted to build a bridge between purely AIO and DIY users. Often, users are scared of the assembly and filling of a DIY system but are generally interested in the topic. We want to give these users the opportunity to enter the world of DIY water cooling in small steps. The Eisbaer was the start; our expandable GPU AIO Eiswolf was the second step. Now, we also offer pre-filled radiators. Further components are in the planning stages. This way, every user can easily build a complete watercooling system without needing to come into contact with the water directly. That's what we want to see with our users: the gradual assembly of a complete water-cooling system where everything can be connected easily with quick-lock connectors.

Q: Do you plan to release additional cooling parts at some point that users can add to their Eisbaer coolers if they expand their systems or just want to extend liquid cooling to other components?

AR: Of course, that's the whole idea behind everything. It's why we're already offering the first true AIO solution for graphics cards, the Alphacool Eiswolf GPX-Pro. It also includes a pump and has already been optimized for graphics cards with HBM. Like always, we've used normal G1/4-inch connectors, which is especially important here since we also offer the Eiswolf without a radiator, just like the Eisbaer. The pre-filled radiators we've already mentioned.

Q: Many of our readers are familiar with Alphacool radiators, but for those who might not be, what can you tell us about the NexXxoS radiators that are part of the Eisbaer coolers?

AR: We are the only company worldwide with real, full-copper radiators. Our competitors are using zinc, steel, or brass for the water channels or the pre-chambers. All parts that come in contact with water

are made of copper in our NexXxoS radiators. That is the biggest and most important difference between us and all other brands worldwide.

Q: Thanks for your time, Andreas! Is there anything else you'd like readers to know about Alphacool's Eisbaer cooler family?

AR: We will be adding more models to the Eisbaer family. Next in line are additional radiator models, such as the simple 140mm radiator and the mighty 420mm radiator. We are also developing the Eiswand (ice wall): an external radiator with a 360mm radiator, six fans, and including the XP3 CPU waterblock, hoses, coolant, and of course the quick-lock connectors. So the Eiswand can also be easily expanded with our new products. Or, it can be used as a stand-alone CPU cooler in Quiet or Power mode. Just wait and see, and thank you for an enjoyable interview. ■



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